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SPECIFICATIONS

FOR

TWO HORIZONTAL DIRECT-ACTING

Triple-Expansion Screw-Engines

FOR

Cruisers Nos. 4 and 5,

OF 4,083 TONS DISPLACEMENT,

The Engines, with their auxiliaries, of ~~10,500~~ 9000 I. H. P. under forced draught;

INCLUDING

BOILERS, SCREW PROPELLERS, AND ALL FOUNDATION AND APPURTENANCES COMPLETE, TOGETHER WITH A LIST OF TOOLS, INSTRUMENTS, AND DUPLICATE PIECES TO BE FURNISHED.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1887.

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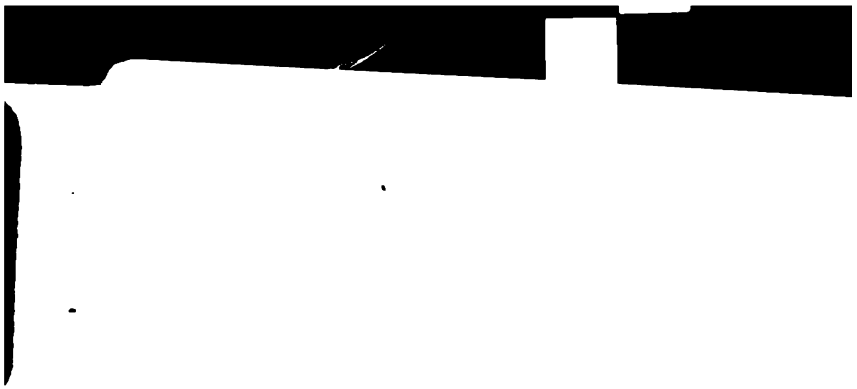

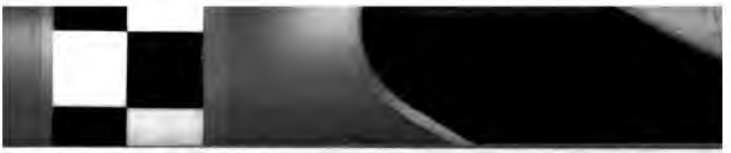

SPECIFICATIONS

FOR

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TWO HORIZONTAL DIRECT-ACTING

Triple-Expansion Screw-Engines

FOR

Cruisers Nos. 4 and 5,

OF 4,083 TONS DISPLACEMENT,

The Engines, with their auxiliaries, of 10,500 I. H. P. under forced draught;

INCLUDING

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N. B. [illegible] Steam Eng.

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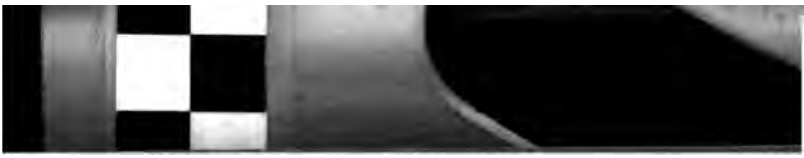

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SPECIFICATIONS

FOR

TWO HORIZONTAL DIRECT-ACTING TRIPLE-EXPANSION SCREW ENGINES AND BOILERS

FOR

CRUISERS Nos. 4 AND 5.

Reference being had to the accompanying drawings, which form a part of these specifications.

GENERAL DESCRIPTION.

The propelling engines will be placed in separate water-tight compartments and will be duplicates; the high-pressure cylinder being the forward one in the forward engine and the after one in the after engine; the forward engine turning the port-propellor. Each propelling engine will have a high-pressure cylinder of 42 inches diameter, an intermediate cylinder of 60 inches diameter, and a low-pressure cylinder of 94 inches diameter; the stroke of all pistons being 42 inches.

The indicated horse-power is to be 10,500 when making about 110 revolutions per minute. The barrels and heads of all cylinders are to be steam-jacketed. The valve-chests are to be cast on the cylinder-casings of the high-pressure and intermediate engines and made separately for the low-pressure engines. The main steam-valves will be double-ported slides working on hard cast-iron seats screwed to the cylinder-faces. The valve-motion is to be of the Stephenson type, with single-bar links, the high-pressure gear being arranged to be linked

up independently of the others. Each piston will have a single piston-rod, with a cross-head working in slipper guides. The cylinder-covers, pistons, and main frames are to be of cast-steel. The cylinder linings to be of cast-iron. The shafting, piston-rods, connecting-rods, and moving parts generally are to be of forged steel.

The condensers will be made entirely of composition, with brass tubes—the exhaust steam passing through the tubes. The total cooling surface will be about 12,500 square feet. There will be one air-pump for each set of engines, worked off the low-pressure piston. Both air-pumps will deliver into a feed-tank in the forward engine-room. The circulating-pumps will be independent, of the centrifugal type, one for each condenser. There is to be in each engine-room an independent pump to be used as a bilge and auxiliary fire-pump; also a pump for fire-purposes only. The propellers are to be three-bladed, right and left, of manganese bronze, 14 feet 6 inches diameter.

There are to be four boilers in two water-tight compartments, with four athwartship fire-rooms, the boilers being placed fore-and-aft. The boilers are to be of the double-ended horizontal return-fire-tube type, 14 feet 8 inches in diameter, to carry a working pressure of 135 pounds per square inch. Each end of each boiler is to have four corrugated furnaces of 3 feet internal diameter. The total heating surface is to be about 16,590 square feet. There will be in each boiler compartment a double inverted cylinder-engine, with two double-acting pumps, to be used for main feed-pumps. There will also be duplicates of these, to be used for auxiliary feed-pumps. The main and auxiliary systems of feed-pipes and valves are to be entirely distinct from each other. There are to be two smoke-pipes, one for the boilers in each compartment. The fire-rooms are to be arranged to work *in plenum*, air being driven in by blowing-fans of sufficient capacity to maintain the necessary air-pressure in fire-rooms. The engines, boilers, and pipes are to be entirely below the protective-deck.

There will be steam-starting and reversing gear, ash-hoisting engines, steam-turning gear for the main engines, an auxiliary condenser with circulating and air-pumps, distilling apparatus, and such other auxiliary or supplementary machinery, tools, instruments, or apparatus as may be described in the following detailed specifications or shown in the official drawings.

HIGH-PRESSURE CYLINDER-CASINGS.

The high-pressure cylinder-casing of each main engine, including the steam and exhaust-ports and passages, inboard-head, valve-chest, and flanges, is to be made of the best cast-iron. It will have, in the cylindrical part, walls 1¾ inches thick. It will be faced at inboard end and bored at outboard end for the reception of the working lining. There will be at the lower part of the inboard-head a flange, truly faced to a plane perpendicular to the axis of the cylinder, for connecting with the engine-frame. This flange will be well ribbed to the walls of the cylinder and will have two ribbed lugs, drilled for 4-inch bolts. There will also be at top of casing a ribbed lug, bored and faced for the attachment of a diagonal stay-rod connecting the cylinder-casing to the crank-shaft pillow-blocks. There will be top and bottom flanges for bolting to the flanges of the intermediate cylinder. These flanges are to be faced to a plane accurately parallel to the axis of the cylinder. The ports and passages are to be smoothly cored. There will be, on the cylinder-casing, facings, flanged and ribbed where necessary, for the attachment of the cylinder-cover, expansion-ring of working lining, valve-seat, valve-chest cover, stop-valve, exhaust-pipe, piston-rod stuffing-box, valve-stem stuffing-box, reversing-engine bed, lower step of reversing-screw, starting-valve chest, starting-valve pipes, relief-valves, drain-cock, cross-head lubricator-bracket, back guide for valve-stem, indicator pipes, jacket steam-pipe, jacket drain, steam port stay-bolts, working-lever brackets, and core-plugs. The inboard steam port will be stayed by three 1⅜-inch bolts.

HIGH-PRESSURE CYLINDER-LININGS.

The working lining of each high-pressure cylinder will be made of close-grained cast-iron, as hard as can be properly worked. It will be 1⅛ inches thick, turned and flanged. It will be securely fastened to the cylinder-casing at the inboard end by counter-sunk steel collar-screws; the joint to be perfectly steam-tight. The outboard end will be turned to a neat fit in the cylinder-casing and the joint will be made steam-tight by a copper expansion-ring, which will be securely fastened to the cylinder-casing and to the working lining by wrought-iron rings, tap-bolts, and studs. The lining is to be smoothly and accurately bored, in place, to a diameter of 42 inches, with proper counterbore at lower end.

HIGH-PRESSURE CYLINDER JACKETS.

The steam-jacket of each high-pressure cylinder will consist of the space between the working-lining and the cylinder-casing and of the hollow of the cylinder-head. The ribs of the head are to be cored out so as to leave passages for the steam and water. Holes are to be drilled to connect the jacket space in head with the jacket around the lining.

The jacketing steam will be taken from the main steam-pipe, outside the engine throttle-valve, and led to the jacket by a 1¼-inch pipe. A drain-pipe is to lead from the lowest part of jacket to an approved automatic trap with blow-through and bye-pass valves, thence to the hot-well, with a branch to bilge; both branches having stop-valves.

HIGH-PRESSURE CYLINDER-COVERS.

The covers of the high-pressure cylinders are to be made of cast-steel, 1¼ inches thick, well ribbed on the outside. Each cover is to be of such form as to leave as little clearance as practicable, and to form the outboard steam passage to the cylinder. It will be faced to fit the cylinder-casing; also faced on outside of flange, bored and faced for the man-hole cover and turned to receive the foundation of lagging. It will be

secured to cylinder-casing by thirty-three 1½-inch steel studs. There will be a facing at lower part, with a 1¼-inch hole for drain-cock. The lower part of each cylinder-cover will be so shaped as to accommodate the wearing-shoe of the piston.

HIGH-PRESSURE CYLINDER MAN-HOLE COVERS.

Each high-pressure cylinder will have a cast-steel cover, of dished form, over the 16-inch man-hole in the cylinder-cover. It will be finished all over on the outside and faced and turned to fit the cylinder-cover. It will be secured by thirteen 1-inch steel studs with finished wrought-iron nuts, and will be provided with forcing-bolts and eye-bolts. The walls of cover are to be not over ⅝-inch thick.

HIGH-PRESSURE VALVE-CHESTS.

Each high-pressure valve-chest, forming part of the cylinder-casing, will have a raised slide at bottom to support the slide-valve, with oil-channels. The channels at the sides of this slide will be provided with drain-cocks. There will be a stuffing-box for valve-stem, with metallic packing, and a composition valve-stem guide at back end. There will be two oil-cups on top of each chest, with internal pipes—one for lubricating the face and the other the back of the valve.

HIGH-PRESSURE VALVE-SEATS.

The high-pressure valve-seats are to be made of hard close-grained cast-iron, and secured to the cylinder-casings by countersunk Tobin's metal collar screws. Each seat will also be secured against end displacement by wrought-iron stops snugly fitted between the ends of seat and the walls of valve-chest and secured in place. The seats to be worked to true planes.

HIGH-PRESSURE STEAM AND EXHAUST-PORTS.

The steam-ports in the high-pressure valve-seats, two for each end of cylinder, will be 35½ inches long and 2¾ inches wide, each with a bridge 3½ inches wide at the middle of its length. The exhaust-port for each cylinder will be 35½ inches long and 6¾ inches wide, with a bridge same as in steam-ports.

HIGH-PRESSURE SLIDE-VALVES.

The high-pressure slide-valves will be double-ported, of hard close-grained cast-iron. The faces are to be worked up to true planes, and each valve will have a faced ring at the back to work under the balance-plate. The valve-faces will have oil-grooves. Each valve to be cored throughout its length, and bored and faced at ends for valve-stems.

HIGH-PRESSURE VALVE-CHEST COVERS.

Each high-pressure valve-chest cover, of cast-steel, will be made of single thickness, ribbed inside and out. It will be secured to valve-chest by forty-four $1\frac{1}{4}$-inch studs. There will be a man-hole in the middle of the cover, with a dished cast-steel plate, having a $1\frac{1}{4}$-inch hole for the relief-pipe of the balancing space. There will be bosses, faced and bored, for the adjusting-screws of the balance-plate and facings for the expansion-ring.

HIGH-PRESSURE SLIDE-VALVE BALANCE-PLATES.

The balance-plate of each high-pressure slide-valve will be made of cast-iron, truly faced to a steam-tight fit on the back of valve. A steam-tight joint will be made with the valve-chest cover by means of a copper expansion-ring, as shown. The plate will be pressed against the valve by four steel springs with adjusting-screws, and by two set-screws with lock-nuts. Side-play is to be prevented by a steel ring bolted to the valve-chest cover, and provided with composition bearing surfaces. This ring to have a drain-hole at bottom.

The balancing space will be connected by a pipe, with valve and pet-cock, to the high-pressure exhaust-port.

HIGH-PRESSURE VALVE-STEMS.

The high-pressure valve-stems, of forged steel, will be finished all over, $2\frac{1}{16}$ inches least diameter. Each will have a left-handed thread at outside end for attachment to link-block, and right-handed threads for nuts inside valve-chest.

The nut at inboard end of valve will be rectangular, fitting a recess in valve, and be provided with a composition clamp with set-screw and lock-nut.

INTERMEDIATE CYLINDER-CASINGS.

Each intermediate cylinder-casing will be of the same material, and fitted similarly to the high-pressure cylinders. The valve-chest, however, will be on top, and there will be two lugs for diagonal stay-rods. There will be flanges to fit those on the high-pressure cylinder, to which they will be securely fastened with body-bound bolts. The walls of casing will be 1⅛ inches thick. There will be facings for the attachment of cylinder-cover, valve-seat, valve-chest cover, high-pressure exhaust-pipe, intermediate exhaust-pipe, piston-rod stuffing-box, valve-stem stuffing-box, valve-stem guide, starting-valve chest, relief-valves, drain-cock, bearing for rocking-lever of valve-gear, indicator-pipes, jacket steam-pipes, jacket-drain, steam-post stay-bolts, core-plugs, and man-hole cover.

INTERMEDIATE CYLINDER-LININGS.

The intermediate cylinder-linings will be of the same material and fitted similarly to the high-pressure linings with the exception of the provision for expansion. This will consist, in each cylinder, of an annular packing-space well filled with India-rubber core packing, covered by a wrought-iron plate, bolted to the cylinder-lining. Each lining will be smoothly and accurately bored, in place, to a diameter of 60 inches, leaving the walls 1¼ inches thick, the counter-bore being similar to that in the high-pressure cylinder.

INTERMEDIATE CYLINDER-JACKETS.

The intermediate steam-jackets will be in all respects similar to those of the high-pressure cylinders, except that the steam-pipe leading to each will have a reducing-valve and a relief-valve. The reducing-valves are to be loaded to 50 pounds per square inch. The relief-valves will be adjusted to 60 pounds per square inch. There will be a stop-valve in each steam-pipe close to jacket.

INTERMEDIATE CYLINDER-COVERS.

The intermediate cylinder-covers will be in all respects similar to those of the high-pressure cylinder, except that each will have two of its studs passing through the outboard steam-port to act as stays.

INTERMEDIATE CYLINDER MAN-HOLE COVERS.

The man-hole cover on each intermediate cylinder-cover will be the same as for the high-pressure cylinder.

The man-hole on the inboard head will be of cast-steel, dished inwardly to fill the man-hole, and secured by eight $\frac{3}{4}$-inch studs.

INTERMEDIATE VALVE-CHESTS.

Each intermediate valve-chest will have a stuffing-box and back guide for the valve-stem, as shown in detail. There will be four oil-cups on top of each chest, two at each end, placed as shown. There will be a spring relief-valve, loaded to 80 pounds per square inch, on each intermediate valve-chest, exhausting into condenser, with gear for raising from working-platform.

INTERMEDIATE VALVE-SEATS.

The intermediate valve-seats will be similar to the high-pressure valve-seats, with the addition of guides at the sides to prevent fore-and-aft play of the valves.

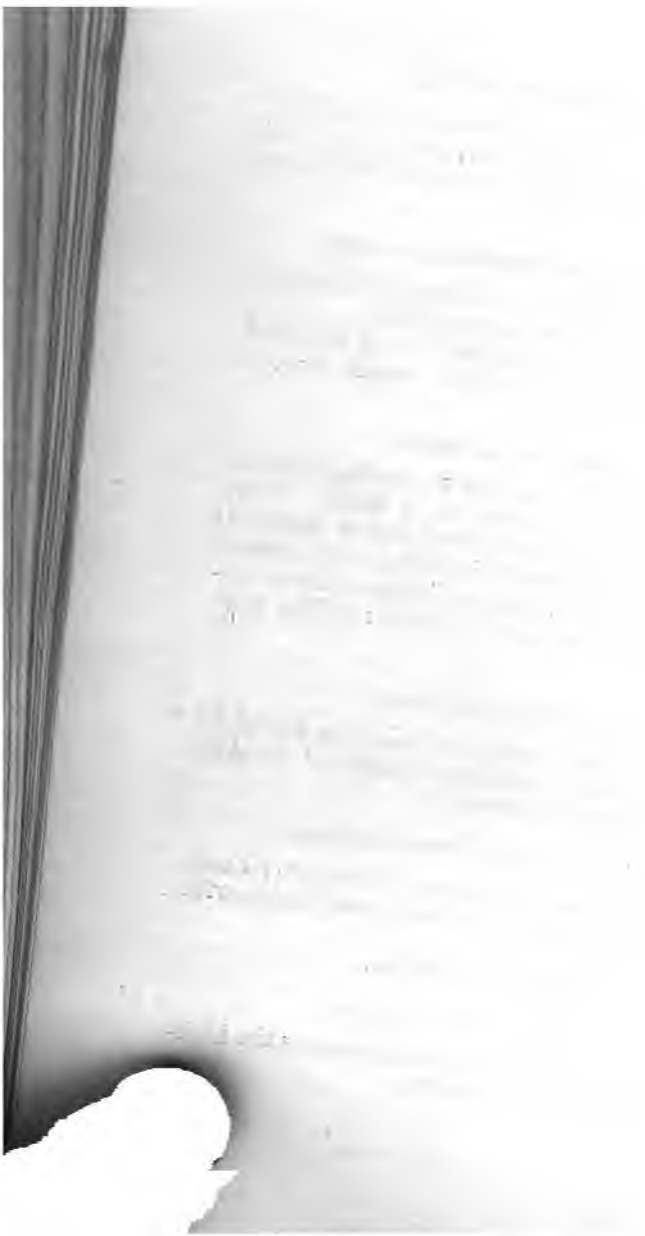
INTERMEDIATE STEAM AND EXHAUST-PORTS.

The steam-ports for each intermediate cylinder, two for each end, will be $57\frac{1}{2}$ x $3\frac{5}{8}$ inches, with two bridges $3\frac{1}{2}$ inches wide in each.

The exhaust-port will be $57\frac{1}{2}$ x $8\frac{1}{2}$ inches.

INTERMEDIATE SLIDE-VALVES.

The intermediate slide-valves will be the same as the high-pressure valves, except as to dimensions.



INTERMEDIATE VALVE-CHEST COVERS.

The intermediate valve-chest covers will be similar to those for the high-pressure chests, except as to dimensions and the arrangement of bosses for balance-plate adjusting-screws.

INTERMEDIATE SLIDE-VALVE BALANCE-PLATES.

The balance-plates of the intermediate slide-valves will be similar to those of the high-pressure valves, except that there will be six springs with adjusting-screws, and that the relief-pipe from the balancing space will lead to the intermediate exhaust passage.

INTERMEDIATE VALVE-STEMS.

The intermediate valve-stems will, inside the valve-chests, be similar to the high-pressure valve-stems. Externally, each stem will be fashioned into a cross-head, with brasses, and with a composition shoe working in slipper-guides carried by the bearings of the valve-gear rocking-lever.

LOW-PRESSURE CYLINDER-CASINGS.

The low-pressure cylinder-casings will be of the same materials as the others, and similarly fitted internally, but will not include the valve-chests, which will be separate castings. The walls of the cylindrical part will be 2¼ inches thick. There will be in each casing, as in the other cylinders, a facing with 4-inch holes for attachment to the engine-frame. There will also be an additional facing, to abut against the frame, close to valve-chest. The framing-bolts will be put in from inside the cylinder, and their heads covered by wrought-iron plates made steam-tight. There will be two lugs at top of casing for stay-rods. The piston-rod stuffing-box will be carried by a separate steel casting, flanged and inserted from inside the cylinder. The walls of steam-ports will be properly stayed. There will be outside facings for the attachment of cylinder-cover, valve-chest, valve-seat, exhaust-pipe, link-block guide, starting-valve pipes, relief-valves, drain-cock,

indicator-pipes, jacket steam-pipe, jacket-drain, steam-port stay-bolts, man-hole cover, cross-head lubricator-bracket, and starting-lever bracket.

LOW-PRESSURE CYLINDER-LININGS.

The working linings of the low-pressure cylinders will be similar to those of the intermediate cylinders, but with walls $1\frac{7}{16}$ inches thick. After being secured in place they will each be smoothly and accurately bored to a diameter of 94 inches, with counter-bores as in the other cylinders.

LOW-PRESSURE CYLINDER-JACKETS.

The low-pressure cylinder-jackets will be similar to those of the intermediate cylinders, taking steam from the same pipes, through the reducing and relief-valves, but with independent stop-valves.

LOW-PRESSURE CYLINDER-COVERS.

The covers of the low-pressure cylinders will be similar to those for the other cylinders, except that each will have a stuffing-box for the air-pump rod. Four of the studs holding each cover will also be used as stays for the steam-passage walls.

LOW-PRESSURE CYLINDER MAN-HOLE COVERS.

The cover of the man-hole in each low-pressure cylinder-cover will be of cast-steel, ribbed outside, and recessed for the piston-rod nut.

The cover for each inboard man-hole will be of steel, dished inwardly to reduce clearance space.

LOW-PRESSURE VALVE-CHESTS.

Each low-pressure valve-chest will be in one casting, of best cast-iron, flanged inwardly, and bolted to cylinder-casing. It will have a raised slide at bottom for supporting the valve, the same as in the high-pressure chests. It will have a flange

for the attachment of the intermediate exhaust-pipe, and will be properly stayed. There will be a stuffing-box for valve-stem. There will be two oil-cups on each chest, with internal pipes, the same as for high-pressure chests. Each valve-chest will have a 4-inch spring relief-valve loaded to 30 pounds per square inch.

LOW-PRESSURE VALVE-SEATS.

The valve-seats of the low-pressure cylinders will be made and secured similarly to those of the high-pressure cylinders.

LOW-PRESSURE STEAM AND EXHAUST-PORT.

The steam-ports in the low-pressure valve-seats, two for each end of each cylinder, will be 82 x 4½ inches, with two bridges in each 3½ inches wide. Each exhaust-port will be 82 x 11 inches.

LOW-PRESSURE SLIDE-VALVES.

The low-pressure slide-valves will be similar to the others except that each will have a pocket at inboard end for the valve-stem nut—the valve-stem not passing through the valve.

LOW-PRESSURE VALVE-CHEST COVERS.

The low-pressure valve-chest covers will be made with double walls, ribbed; and will have plate covers bolted on over core-holes on the inside. Each cover will be fitted for six balance-plate springs and for two set-screws. Otherwise each cover will be fitted the same as for high-pressure.

LOW-PRESSURE SLIDE-VALVE BALANCE-PLATES.

The balance-plates on backs of low-pressure valves will be fitted similarly to those on the intermediate valves. The relief-pipes, each with stop-valve, and a pet-cock between stop-valve and valve-chest cover, will lead to the low-pressure exhaust-pipe.

LOW-PRESSURE VALVE-STEMS.

The stems of low-pressure valves will be fitted outside similarly to those for high-pressure valves. Inside the valve-chest each stem will be screwed into a rectangular composition nut pocketed in the end of the valve. Each nut will have a composition clamp with set-screw and lock-nut. The diameter of valve-stem, over thread, will be 4 inches.

CYLINDER SUPPORTS.

Besides being secured to the pillow-blocks by the lower frame and by the diagonal stay-rods, each cylinder will be supported near its outboard end by a cast-iron chock bolted to the engine-seatings and fitted neatly under the barrel of the cylinder-casing.

EXHAUST-PIPES.

The exhaust-pipes from high-pressure to intermediate cylinders and from intermediate to low-pressure cylinders will be made of copper, with composition flanges. They will be made short and drawn up to place to allow for expansion. On the exhaust-nozzle of each low-pressure cylinder will be bolted a composition elbow, stayed internally, with facings for the attachment of the low-pressure starting-valve chest and for the exhaust-pipe from the other starting-valves and from the reversing-engine. From this elbow a straight composition pipe will lead to the condenser, and be fitted thereto with a stuffing-box.

CYLINDER CLOTHING.

The cylinders, valve-chests, and exhaust-pipes, after being tested and finally secured in place in the vessel, are to be covered with approved incombustible non-conducting material and neatly lagged with black walnut all over, with polished brass bands and brass lag-screws.

The lagging is to be made in removable sections over each cylinder-cover, man-hole cover, valve-chest cover, and starting-valve chest-cover. The sections to be of such size as to be easily handled, and all parts marked. The lagging elsewhere is to be so secured as to be easily removed, replaced, and repaired.

MAIN PISTONS.

The main pistons are to be made of cast-steel, with shells $2\frac{1}{2}$ inches thick at hub and $1\frac{3}{4}$ inches at periphery. The followers are to be of cast-steel, secured by $1\frac{1}{8}$-inch square-headed wrought-iron collar-bolts screwed into composition bushings. These bushings are to be screwed into the pistons and secured by stop-pins. Each piston will have two cast-iron packing-rings, each about $\frac{5}{8}$ inch wide and $\frac{3}{4}$ inch thick, set out by steel springs of proper tension. The rings are to be cut, sprung in, and turned to the diameters of the cylinders. The springs are to be of the best spring-steel, properly tempered. The pistons must work steam-tight without undue friction. There will be a cast-iron shoe at the bottom of each piston for at least one-third of the circumference, secured to the follower by steel studs in slotted holes, to allow of vertical adjustment. The bottom of each shoe will be lined with strips of approved anti-friction metal. The lengths of bearing of the shoes in the direction of the axes of the cylinders must be at least 7, 9, and 11 inches for the high, intermediate, and low-pressure cylinders, respectively.

The bosses of pistons are to be bored taper to receive the piston-rods, and faced for the piston-rod nuts. The low-pressure pistons will each have a boss, bored and faced for the air-pump piston-rod.

PISTON-RODS.

The piston-rods are to be of forged steel, $8\frac{1}{2}$ inches diameter. They will be turned taper to fit the pistons, and fitted, each, with nut and keeper. The parallel parts are to be smoothly and accurately turned. The inboard end of each piston-rod

will be enlarged to form a cross-head, and will be fitted with adjustable brasses, with steel cap secured by steel bolts with recessed nuts and set-screws. The brasses are to be bored to 8½ inches diameter.

CROSS-HEAD SLIPPERS.

A wrought-iron slipper will be dovetailed and shrunk on the bottom of each cross-head and further secured by tap-bolts. The slipper will be finished all over, and will be covered on top with composition about ¼ inch thick, pinned on and finished. A composition guide-gib will be fitted to the bottom of each slipper, secured at inboard ends by a flange and studs and at the outboard end by square-headed bolts in slotted holes. Each gib to be finished with white-metal plugs and with oil-grooves.

PISTON-ROD STUFFING-BOXES.

The main piston-rod stuffing-boxes are to be made of cast-steel, with composition bushings at bottom. The high-pressure and intermediate stuffing-boxes are to be fitted with metallic packing, and the low-pressure boxes fitted for soft packing. The glands are to be of composition, and fitted with pinion-nuts and spur-rings, set up by worm-gear. Each gland will be fitted with a small auxiliary gland, with oil-groove, forming a keeper for the spur-ring.

CONNECTING-RODS.

The connecting-rods will be made of forged steel, and, with their fittings, finished all over. Each rod will be forked at the cross-head end, and each eye at that end will be split and fitted with a bolt for griping the cross-head pin. The pin will be finished to a neat fit, inserted in the eyes, and securely clamped.

The crank-pin end will be finished with a steel cap and bolts with recessed nuts and set-screws. The rod and cap will be separated by chipping-pieces and brass liners, held in place

by dowels. The caps and brasses will be fitted with eye-bolts for handling. The connecting-rods will be 7 feet between centers, 6 inches diameter at cross-head end and 7 inches at crank-pin end.

CRANK-PIN BRASSES.

The crank-pin brasses are to fit the connecting-rod ends and caps neatly. They will have proper clearance at top and bottom, and will be lined with approved anti-friction metal. Each brass will be held in place by four tap-bolts, two at top and two at bottom, with set-screws.

The brasses are to be $\frac{1}{8}$ inch shorter than the pins.

ENGINE STOP-VALVES.

There will be a double-seated equilibrium stop-valve bolted to each high-pressure cylinder-casing. It must be steam-tight when hot, and so proved. It will be worked through bevel-gearing by a hand-wheel at the working-platform; also from the main-deck by approved gearing. The hand-wheels are to be provided with suitable indices to show the positions of the valves.

THROTTLE-VALVES.

There will be a throttle-valve, to be worked by the governor, bolted to the stop-valve of each propelling-engine. The valve will be of the butterfly pattern. It must work freely when hot, at the same time being as tight as possible. The valve-casing will have a stuffing-box for attachment to the main steam-pipe.

STARTING-VALVES.

There will be a starting-valve for each cylinder of the propelling-engines. Each valve is to be complete in itself, with both steam and exhaust-ports. The valves and chests will be of composition. Each valve will have a rib on its back, working close under the cover of its chest, to prevent

the valve rising off its seat. The covers of chests to be of wrought-iron, finished. The valves to be securely fastened to their stems. The valve-chests to be bolted to the facings provided for them. Steam for the starting-valves will be taken from the main steam-pipes outside the throttle-valves by a pipe having a branch to each valve. There will be a stop-valve in this pipe, to be worked from the working-platform; also a stop-valve close to each valve-chest. Each starting-valve will connect with each end of its cylinder by a copper pipe. The high-pressure and intermediate starting-valves will exhaust into a pipe leading into the low-pressure exhaust-pipe, with a valve at each starting-valve chest. Branches from these steam and exhaust-pipes will lead to the reversing-engine, with a stop-valve in each. The low-pressure starting-valve will exhaust directly into the low-pressure exhaust-passage. Each starting-valve will be worked by a lever at the working-platform; these levers to be placed in the same order as their respective valves, and to move in the same direction as the desired motion of the pistons. The valves are to be in middle position when their levers are vertical. The starting-valve faces and seats to be scraped to perfect steam-tight joints.

CYLINDER RELIEF-VALVES.

There will be an adjustable spring relief-valve on each end of each main cylinder, of the following diameters: high-pressure relief-valves, 3 inches; intermediate relief-valves, 3½ inches; low-pressure relief-valves, 5 inches. Pipes will lead from the intermediate relief-valves to the bilge, with easily broken joints. The studs holding each valve-casing to the valve-nozzle will be long enough to allow the nuts to be entered without slacking back the spring adjustment. The springs are to pass satisfactory tests.

CYLINDER DRAIN-COCKS.

There will be a drain-cock on each end of each main cylinder, of the following diameters of opening: high-pressure

drain-cocks, 1¼ inches; intermediate drain-cocks, 1½ inches; low-pressure drain-cocks, 2 inches. The cocks to be perfectly tight without undue friction. The drain-cocks of the high-pressure and intermediate cylinders of each engine are to be worked by a single lever, and those of the low-pressure cylinder by a separate lever, both at the working-platform. All the drain-cocks of each engine will discharge into a pipe leading to the fresh-water side of the condenser, with a branch to the bilge. The cock connecting the two branches must be such that one branch must always be open, but without permitting air to enter the condenser. Small drain-cocks will be fitted in the lowest parts of drain-pipes.

VALVE-GEAR.

The valve-gear is to be of the Stephenson type, and must be so adjusted as to cut off steam at such a point as shall give the maximum engine-power before specified, at the same time giving sufficient steam and exhaust lead and compression. The adjustment is also to be such that the points of cut-off at both ends of each cylinder shall be as nearly as possible equal. The adjustment for backing-gear is to be as nearly as possible the same as for ahead-gear.

ECCENTRICS.

The eccentrics are to be of cast-steel; those for the forward high-pressure engine and for the after low-pressure engine each to be cast whole; all others to be in two parts, securely bolted together. They will be bored to fit the shafts snugly, and will be held in place each by a key and set-screw. They will be truly turned to dimensions as follows: high-pressure eccentrics, 4⅞ inches eccentricity and 4½ inches face; intermediate eccentrics, 6½ inches eccentricity and 4½ inches face; low-pressure eccentrics, 7¾ inches eccentricity and 4⅞ inches face. They will be finished all over except where cored out.

ECCENTRIC-RODS AND STRAPS.

The eccentric-straps will be made of wrought-iron, and an extension of one-half of each strap will form the eccentric-rod. The straps will be bushed with composition, pinned in place. Chipping-pieces will be fitted between the two parts of each strap, the latter being held together by two $1\frac{3}{4}$-inch steel bolts for each high-pressure and intermediate strap, and by two $2\frac{1}{8}$-inch bolts for each low-pressure strap. These bolts to have square heads and wrought-iron nuts with keepers. The link-ends of the eccentric-rods are to be forked and fitted with neatly fitting steel pins, secured from turning. Each ahead eccentric-rod pin is to be prolonged outside the eye of rod and be fitted with a steel thimble for the suspension-link connection.

LINKS.

The links will be of the single-bar pattern of forged steel. Those for the high-pressure and intermediate engines will have a mean radius of 6 feet 2 inches and a cross-section of $4\frac{1}{4}$ x $5\frac{1}{4}$ inches. Those for the low-pressure engines will have a mean radius of 6 feet 6 inches and a cross-section of $4\frac{1}{8}$ x $5\frac{1}{4}$ inches. The ends will be fitted with octagonal split brasses, adjustable by set-screws and lock-nuts, for eccentric-rod pin connection. The ahead eccentric-rods will engage with the lower ends of the links.

LINK-BLOCKS.

The link-blocks will be of wrought-iron with adjustable brasses. At the back of each block a cast-iron slipper will be bolted, to work in the link-block guide. The brasses of each block will be in two pieces, fitting accurately on the curved sides of the link. The outsides of the brasses will be turned to a circular form, and will work between the adjustable jaws of the link-block. These jaws to be adjustable by set-screws, lock-nuts, and clamp-bolts. The valve-stem of each high and low-pressure engine will be screwed directly into its link.

block and clamped by a rectangular steel nut with stud and clamping-nut. The low-pressure link-blocks will each have an eye, with brasses, to connect with the rocking-lever links.

LINK-BLOCK GUIDES.

Each link-block will be carried in adjustable guides. The guides for the high-pressure and intermediate link-blocks will be carried by cast-iron standards bolted to the engine-frames. Those for the low-pressure engines will be carried by brackets bolted to the low-pressure cylinder-casings, and additionally supported by stanchions bolted to the engine-frames. The lower gib of each guide will be made of wrought-iron, faced with composition, and will be adjustable by means of slotted holes and clamping-bolts.

INTERMEDIATE VALVE-GEAR ROCKING-LEVERS.

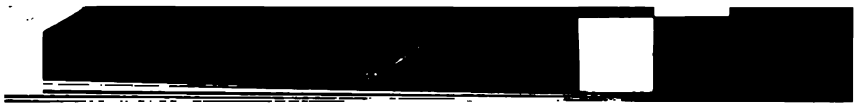
The intermediate slide-valves will be worked off the link-blocks through rocking-levers. Each rocking-lever, of wrought-iron, will be about 4 feet 11 inches between end-centers. It will have a steel pin shrunk in to form a double central journal, and will have adjustable brasses in eyes at ends. The lever, being inclined, will have a composition bearing-washer on the lower side of central boss. The rocking-lever will be connected to link-block and to valve-stem, each by a double wrought-iron link with steel pins.

ROCKING-LEVER BEARINGS.

Each intermediate valve-gear rocking-lever will be carried in adjustable bearings bolted to the intermediate cylinder-casing. The same casting which carries these bearings will form a guide for the valve-stem cross-head and will have a facing for attachment of piston-rod cross-head lubricator.

SUSPENSION-LINKS.

Each valve-gear link will be suspended from the corresponding arm of the reversing-shaft by a wrought-iron link, with adjustable brasses at top and fixed brasses at bottom. All suspension-links to be of equal lengths between centers.



REVERSING-SHAFTS.

There will be a forged-steel reversing-shaft, finished all over, running the entire length of each engine, underneath the bed-frames. It will carry four arms, three for working the various links and one for connecting to the rock-shaft of the reversing-engine. The shaft will be 8 inches diameter at middle and 7 inches at ends. The after end will carry a counterbalance-lever with a cast-iron and lead weight—the exact weight required being found by balancing the gear when in complete working order but not connected to valve-stems or screw of reversing-gear. The reversing-arms for the intermediate and low-pressure cylinders will have suspension-pins forged on. The high-pressure reversing-arm will be slotted, the suspension-pin being adjustable by means of a screw with hand-wheel with a suitable index. All arms to be of wrought-iron, finished all over. The reversing-shaft will be connected to the reversing-engine rock-shaft by a wrought-iron link with forked ends, and with steel pins working in bushed eyes in their respective arms.

REVERSING-SHAFT BEARINGS.

Each reversing-shaft will be carried in four bearings suspended from the engine-bed frames. The brackets and caps of these will be of cast-steel. The bearings are to be adjustable, with composition boxes.

REVERSING-ENGINES.

Each reversing-engine will consist of two 7 x 6-inch engines, with disc-cranks at right angles, working, by means of worm and bevel-gearing, a screw whose nut, traveling in guides, will have a link connection to the reversing-engine rock-shaft. This rock-shaft will be carried in two bearings on top of the engine bed-frame. The reversing-engine will be reversed by means of a slide-valve changing the ports to steam or exhaust at will. This valve is to be worked by a reversing-lever at the working-platform; also by an automatic gear which will

throw the reversing-valve over before the engine can bring up. The reversing-lever must have no catches, but will have an approved clamping-gear to hold it in mid-position when not in use. There will be a hand reversing-wheel connected by bevel-gearing to the worm-wheel shaft. Both steam and hand-gears will have clutches by which they can be thrown in or out. The hand-gear will be held in any position desired by a hinged stop, which can be dropped between the spokes of the wheel. All the slide-valves will have guides to prevent them leaving their seats. Each reversing-engine will take steam from the starting-valve steam-pipe, and will exhaust into the starting-valve exhaust-pipe. There will also be an exhaust connection to the auxiliary exhaust-pipe. A separate steam-pipe with its own stop-valve will lead from the auxiliary steam-pipe to each reversing-engine.

ENGINE FRAMING.

The frames of each propelling-engine will be as follows:

A cast-steel frame, made in four pieces, containing the crank-shaft pillow-blocks.

Three cast-steel bed-frames, connecting the pillow-block frame to the lower parts of the cylinders, and supporting the cross-head slides, reversing-engine rock-shaft bearings, and link-block guides.

Five forged-steel diagonal stay-rods, connecting the pillow-blocks to tops of cylinders.

CROSS-HEAD SLIDES.

The cross-head slides will be made of cast-steel and will be supported by the engine bed-frames. The high and low-pressure slides will be cast separately and bolted to the frames. The intermediate slides will form part of the bed-frame casting. They will be smoothly and accurately finished, with opposite sides parallel, and will be fitted in place to proper alignment. Oil channels will be cut where necessary. Brass oil-boxes will be bolted to ends of slides.

ENGINE BED-FRAMES.

The engine bed-frames will be made of cast-steel, hollow and well ribbed. They will have broad flanges, accurately faced to true planes on bottoms for bolting to engine-seatings. The facings for attachment to cylinders and pillow-blocks must be accurately perpendicular to the bottom faces. They will be bolted to the cylinders by 4-inch body-bound steel bolts in reamed holes, and to the pillow-blocks by 1½-inch wrought-iron bolts. These frames will support the cross-head slides as before specified. The high-pressure frame will carry two adjustable bearings for the reversing-engine rock-shaft. To the bottom face of this frame will be bolted two of the bearings of the reversing-shaft. Each low-pressure frame will have a facing for the attachment of one of the reversing-shaft bearings. The high-pressure and intermediate frames will have facings for the attachment of the link-block guide-standards. Each low-pressure frame will have a facing to support the stanchion under the link-block guide-bracket.

CRANK-SHAFT PILLOW-BLOCKS.

The crank-shaft pillow-block frames will be made of cast-steel, each in four parts, bolted together. They will be hollow, well ribbed, and will have broad flanges faced to true planes for bolting to the engine-seatings. The facings on the cylinder side of the frames must be in planes accurately perpendicular to the faces of bottom flanges. These frames will be extended upward to form the pillow-blocks, four for each propelling-engine. Each pillow-block will have a cast-steel cap, which, together with the jaws, will be bored and faced for the brasses.

The cap-bolts will be of forged-steel, 3¾ inches diameter. The lower ones will be through-bolts. The upper bolts will have enlarged heads, drilled and tapped for attachment of stay-rods. The caps will be finished all over, and must be neatly fitted to the pillow-block jaws. The nuts will be secured by collars and set-screws. There will be two 3-inch holes in

each cap for the purpose of feeling the brasses. The caps will be fitted with eye-bolts for handling. On the pillow-block frame of each engine will be a facing for attachment of one of the bearings of the reversing-shaft.

CRANK-SHAFT PILLOW-BLOCK BRASSES.

The crank-shaft pillow-block brasses will be made of composition, lined with anti-friction metal. Each bottom-brass will be turned to fit the curve of the pillow-block jaws, and must be easily removable when the shaft is in place. Each crown-brass will be faced to accurately fit the jaws. The brasses will be separated by composition chipping-pieces, secured by studs, and easily removable when the brasses are in place. The crown-brasses will be cored out at back, and each must have a true bearing against the pillow-block cap. The brasses will be finished all over except where cored. Each brass must be tapped and fitted with eye-bolts for handling. After the engines are secured in the vessel the brasses will be bored out in place to proper alignment.

DIAGONAL STAYS.

The diagonal stays between crank-shaft pillow-blocks and cylinders will be of forged-steel, 5½ inches diameter, finished all over. All the stays of each engine except the outside one at the low-pressure end will be swelled at the pillow-block end, finished in tap-bolt form to 4¼ inches diameter, and tightly screwed into heads of pillow-block cap-bolts. The stay at the low-pressure end of engine will be T-headed and secured to pillow-block cap-bolts by two 4¼-inch steel tap-bolts. At the cylinder ends all stays will be swelled, turned, and tapped for 4¼-inch steel bolts, which will secure them to the lugs on cylinders. After the engines are secured, with proper alignment, in the vessel, neatly fitting finished wrought-iron washers will be inserted between the stay-ends and the cylinder-lugs, and the bolts set up firmly.

SHAFTS.

All of the crank, line, thrust, and propeller-shafts are to be of steel. Each length, except crank-shafts, will be forged solid in one piece, and will have a hole drilled axially through it from end to end. Or, if made of fluid-compressed steel and hydraulic forged, each length may be drawn out on a mandrel from a hollow ingot.

All shafts are to be finished all over.

CRANK-SHAFTS.

The crank-shafts will be 15 inches diameter in the main journals, 15½ inches in the crank-pins, and 16 inches in the eccentric-seatings. The journals and crank-pins will have 7-inch axial holes. The crank-pins will be 16 inches long. The crank-shafts may, if desired, be built up in such manner as may be approved. The crank-webs will be 11¼ inches thick and 17 inches wide, if made solid. If built up, the after crank-web will be increased to 12 inches in thickness, and the metal in the eyes of the webs will be 6 inches thick at the crank-pin ends and 7 inches thick at the shaft ends. The cranks will be at angles of 120° with each other, each with a throw of 21 inches. The crank-pins must be accurately parallel to the main journals. All journals are to be smoothly and accurately turned, and when finished will be tested and their accuracy proved.

LINE-SHAFT.

The port-crank shaft will be connected to the thrust-shaft by a line-shaft in one length of about 28 feet 10¾ inches over all. It will be 14 inches diameter with an 8-inch axial hole. It will have a flange-coupling at each end, and will be increased to 15½ inches diameter at forward end to form a seating for the turning-wheel.

It will be carried in one bearing, elsewhere specified.

THRUST-SHAFTS.

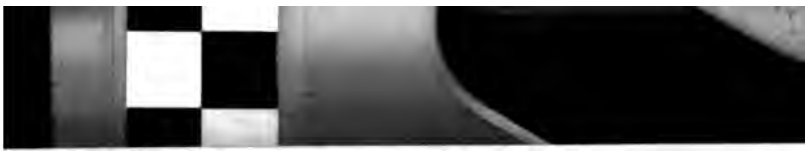
Each thrust-shaft will be about 16 feet 3 inches long, and will be 14 inches diameter with an 8-inch axial hole. It will have flange-couplings at both ends. The starboard shaft will be increased to 15½ inches at the forward end to form a seating for the turning-wheel. There will be eleven thrust-collars 19½ inches diameter and 1⅝ inches thick. The diameter of the shaft between collars will be increased to 15¼ inches diameter. Each shaft is to be carried in a bearing abaft the thrust-bearing: no part of the weight is to be taken by the thrust-bearing.

PROPELLER-SHAFTS.

Each propeller-shaft will be in one length, about 56 feet 2⅛ inches over all, 15 inches in diameter except at outer bearing in stern-tube, where it will be increased to 15$\frac{1}{16}$ inches. The axial hole will be 9 inches diameter. The shaft will be cased in composition for about 14 feet 5½ inches where it passes through the stern-tube, and for about 5 feet 9⅞ inches in the bearing of the stern-bracket. This casing will be shrunk and pinned on at the bearings, but between the stern-tube bearings will be carried clear of shaft. The different lengths of casing must be made perfectly water-tight at their junctions. The casings must be accurately and smoothly turned, to form journals. The forward end of shaft will be reduced to a diameter of 14¾ inches for a length of 13⅞ inches to receive the coupling-sleeve elsewhere specified, and will have three splines for 2½ x 2½-inch feather-keys. The after end will be tapered from 15 inches to 12¼ inches diameter in a length of 2 feet 10 inches to fit the bore of propeller-boss, and will have a spline for a 3 x 3-inch feather-key. Abaft this the diameter will be reduced to 10 inches, threaded and fitted with a nut and keeper, the thread being turned off the part abaft the nut. There will be a water-tight plug in the after end.

SHAFT-COUPLINGS.

The crank, line, and thrust-shafts will be connected by flange-couplings forged with their respective shafts. These will all



be turned 2 feet 5½ inches diameter and faced 3½ inches. The after ends of crank and line-shafts will have projections 15⅞ inches diameter, fitting corresponding recesses in the forward part of line and thrust-shafts, respectively. The bolt-holes will be equally spaced and accurately drilled to template 3½ inches diameter, five in each coupling. The bolts will be of forged-steel and must fit holes snugly.

The after ends of thrust-shafts will each have a coupling-flange of same dimension as the others, but drilled for six 3½-inch bolts. The forward end of each propeller-shaft while in place will have a wrought-iron sleeve 2 feet 7 inches diameter and 15 inches long put on, and keyed by three 2½ x 2½-inch feathers. The sleeve will be secured to the shaft by a wrought-iron washer 15⅞ inches diameter, fastened to the shaft by a steel stud and nut to take the backing-thrust. This washer will fit a recess in the after end of thrust-shaft. The bolt-holes will be drilled to fit those on thrust-shaft coupling. The bolts will fit the holes in sleeve snugly at forward end only, and will be loose in the after part.

SHAFT PILLOW-BLOCKS.

The line and thrust-shaft pillow-blocks will be of cast-iron, with wide flanges, faced and bolted to the seatings provided. The caps will be secured each by four 1⅛-inch wrought-iron bolts. The holding-down bolts will be 1¼ inches diameter in 1⅜-inch holes. Each cap will have a grease-cup cast on, with hinged cover. Each bearing will be lined with anti-friction metal for a length of 26½ inches.

THRUST-BEARINGS.

Each thrust-bearing pedestal, of cast-iron, will be firmly bolted to the seating provided, and bored out to receive the lower part of bearing. The bearing will be in two parts, of cast-iron, with white-metal linings. The lower part will be turned to fit the pedestal, in which it will be adjustable, fore-and-aft, by two set-screws at each end, with lock-nuts. The

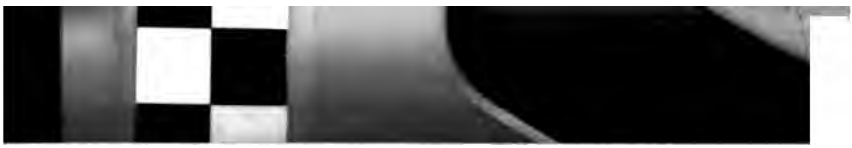
upper part, or cap, will be separated from the bottom by composition distance pieces, and will be fitted in place with six $1\frac{5}{8}$-inch wrought-iron dowel-pins, fitting snugly in holes in the lower part of bearing. The cap will be faced to fit longitudinal recesses in the upper flanges of pedestal, and will be held down by eight $1\frac{5}{8}$-inch wrought-iron bolts, body-bound in pedestal, but with slotted holes in cap. Each cap will have a box cast on top, divided into two parts, one for oil, the other for water; the former having a hinged cover. There will be a hole for oil and another for water, leading down to each collar and each recess, the white metal being properly channeled. The oil-box will be divided by athwartship partitions.

STERN-TUBE BEARINGS.

Each stern-tube, fitted by the hull contractors, will be finished by the engine contractors as follows: A composition lining, turned to fit the stern-tube, will be inserted from the inner end and secured by a water-tight flange-joint. This lining is to be about $1\frac{1}{4}$ inches thick at forward end and $1\frac{5}{32}$ inches at after end, and will be about 12 feet $3\frac{1}{2}$ inches from face of flange to after end. A prolongation of the forward end of the lining will form the stuffing-box casing. The lining will be bored out at forward and after ends and will be fitted with sections of lignumvitæ. The lengths of the lignumvitæ bearings will be 2 feet 6 inches at each end. The lignumvitæ will be prevented from turning by a composition strip screwed to the tube-lining, and will be properly channeled for the circulation of water. The after end of the lining will be finished by a conical ring, smoothly turned, bolted on, forming with the after end of the forward shaft-casing a clean run from the stern-tube to the shaft. The lignumvitæ must bear on end of grain and will be smoothly and accurately bored out, in place, to suit the shaft-casing.

STERN-TUBE STUFFING-BOXES.

A composition ring will be inserted in the forward part of each stern-tube lining to form the bottom of the stuffing-box,



and will be pinned in place. The gland will be of composition, with Tobin's metal bolts, fitted with pinion-nuts and spur-ring. The packing space is to be about 6 inches deep and $1\frac{1}{8}$ inches wide. There will be a $1\frac{1}{2}$-inch drain-cock with pipe leading to engine-room bilge.

STERN-BRACKET BEARINGS.

Each stern-bracket is to have a neatly-fitting composition lining, about $1\frac{5}{32}$ inches thick, inserted from the after end and secured by a flange-joint. It will be fitted with a lignum-vitæ bearing about 4 feet 8 inches long, fitted as in the stern-tubes, and bored out in place to suit the shaft-casing. The lignumvitæ will be held in place at the after end by a flat ring, pinned on, and at the forward end by a conical ring similar to those at after ends of stern-tubes. A light steel sleeve, with interior reinforce ring, will be properly secured to each stern-bracket, and will be so shaped as to make a fair water-line to the propeller-boss.

SCREW-PROPELLERS.

The screw-propellers are to be made of manganese bronze. The starboard propeller is to be right-handed and the port one left-handed. They are to be three-bladed, about 14 feet 6 inches in diameter. The area and pitch will be as may be hereafter determined. The blades will be securely bolted to the boss by naval-brass tap-bolts secured by lock-plates. The holes in the blade flanges will be slotted to allow of an adjustment of pitch. The recesses for the bolt-heads are to be covered by composition plates, held by countersunk screws, and finished to form a smooth surface, fair with the boss. Each boss is to be accurately bored to fit the taper on after end of shaft, and fitted with a wrought-iron feather-key 3 x 3 inches in cross-section. Each propeller will be held on the shaft by a nut, screwed on and locked in place. The shaft-casing is to enter about 1 inch into the propeller-boss and to be fitted water-tight. Each boss will be finished at the after end by a composition cap, bolted on water-tight. The bosses and caps will

be finished all over. The blades will be cast as smooth as possible, and will have any roughness removed. The flanges of the blades are to be turned and faced to fit the recesses in the bosses accurately, and after being secured in place must have the edges made fair.

MAIN CONDENSERS.

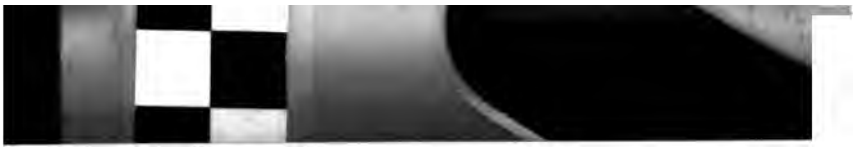
The shells of the main condensers are to be built up of cast sections of as nearly as possible the same composition as the tubes.

The flanges of the various parts are to be accurately faced, recessed into each other where possible, and fastened together with Tobin's metal bolts. The various parts are to be well ribbed and stayed by $1\frac{1}{8}$-inch rods at right angles to tubes and by $\frac{7}{8}$-inch rods in the same direction as tubes.

Each condenser will be supported by its air-pump casing, and by a seating to which will be bolted two flanged feet at the back end of condenser. The main casing will have faced flanges for its attachment to air-pump, and facings for the attachment of the circulating-water entrance and exit-pipes, three man-hole plates on bottom, two man-hole plates on sides, salt-feed pipe, and drain-cocks.

The tube-sheets are to be of Muntz metal, $\frac{3}{4}$ inch thick, drilled for the tubes, and drilled and tapped for the glands. The glands for tube-packing at both ends of condenser are to have collars to prevent tubes from crawling. There will be in each condenser 4,256 solid-drawn brass tubes, 7 feet 6 inches between tube-sheets, $\frac{3}{4}$ inch outside diameter and 0.05 inch thick. Tape packing is to be used. There will be a division-plate of $\frac{1}{4}$-inch Muntz metal, supported by the middle row of stays, to regulate the flow of the condensing water.

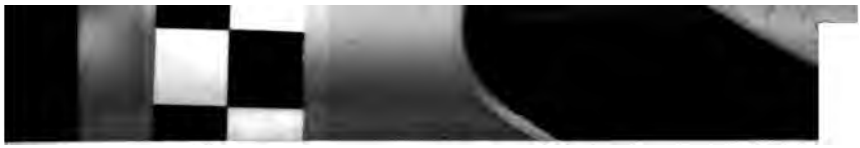
There will be a composition chest bolted to the front end of the condenser with a flange for the attachment of the main exhaust-pipe stuffing-box; also facings for a man-hole plate, bleeder-pipe, cylinder drain-pipe, circulating-pipe, salt-feed pipe, soda-cock, and drain-cocks.



The chest at the back end, also of composition, will have two man-holes and a flanged opening for attachment of the air-pump suction-pipe. Composition plates are to be fitted to all man-holes. One of the man-hole plates will have attached to it a 1⅜-inch spring relief-valve. There will be a tank, pipe, and cock fitted for the purpose of admitting an alkaline solution into each exhaust-passage. Drain-cocks will be fitted on salt and fresh-water sides of condenser, where needed, with pipes leading to bilge. A salt-feed cock will be fitted on each condenser. No part of the machinery, except such as can be easily removed, will be placed where it will interfere with drawing and replacing the condenser-tubes. The condensers must be perfectly tight in all joints, and be so proved after being secured in place. The chests at the exhaust-steam end of condensers will be clothed and lagged similarly to the cylinders, with removable portions where required.

AIR-PUMPS.

There is to be one horizontal double-acting air-pump for each condenser, worked off the low-pressure piston of the corresponding propelling-engine. The pump-cylinder will be 28 inches diameter, the stroke of piston 42 inches. All parts of casings, pump-barrels, covers, valve-seats, and pistons will be of composition. The working linings of the pump-barrels will be cast separately, turned to fit casing, forced in and pinned, and bored out in place. The piston-rods are to be of rolled Tobin's metal, each to be fitted with a steel nut at the steam end. The pistons will be cast hollow and ribbed, and will have followers secured by ⅞-inch Tobin's metal bolts. The valve-seats are to be made separately and bolted in, and must be smoothly faced. There will be six 7¼ x 11¾-inch double-flap India-rubber valves in each suction-seat and nine of same size in each delivery-seat, all with inclined perforated guards. The suction side of each air-pump will be connected with the condenser by a composition pipe, forming part of the condenser support. The hot-wells will have flanges at top, bolted to condenser.



There will be bonnets for getting at both ends of pump; also for foot and delivery-valves. A glass gauge is to be fitted to the suction side of each pump. Each end of each pump is to have a $\frac{7}{16}$-inch adjustable air-valve and a $6\frac{5}{8}$-inch spring relief-valve with a pipe leading toward the bilge but with the end in sight. The two hot-wells of the after air-pump will be connected by a $6\frac{5}{8}$-inch pipe, and from the inboard hot-well a 6-inch pipe will lead to the feed-tank. On the forward air-pump the discharge-pipe to feed-tank will connect with both hot-wells. There will be bolted to one of the hot-wells of each air-pump a valve-box with three non-return valves and connections, for the attachment of the drain-pipes from the steam-jackets. A circulating pipe, with valve, will lead from each inboard hot-well to the fresh-water side of the condenser at the exhaust-steam end. There will be a facing on each air-pump below the foot-valves for the attachment of a suction-pipe to the feed-pumps. Each air-pump, together with the condenser, must maintain a vacuum of within four inches of mercury of the weather barometer with the propelling-engines at full power under forced draught. Each air-pump will be firmly and securely bolted to its seating with its cylinder properly aligned with the main engines.

MAIN CIRCULATING-PUMPS.

The main circulating-pumps, one for each main condenser, will be of the centrifugal type, of composition.

Each pump is to have a fan of 3 feet 6 inches diameter, with double inlet 14 inches diameter. There will be flanges on the casing for 17-inch inlet and delivery-pipes. The casing is to be in two parts, divided horizontally, so that the upper part when removed will expose the fan and bearings. The fan-casing, wings, and shaft are to be in one casting, smoothly cored, finished where possible, and perfectly balanced. The bearings will consist of sections of lignumvitæ, on end of grain, dovetailed into composition split sleeves, which will be well secured against turning. The stuffing-box gland will be in two parts. The shaft must be

smoothly and accurately turned to 4½ inches diameter. There will be an air-cock at top of pump-casing and a drain-cock at bottom. Each pump is to be firmly bolted to its seating in perfect alignment with its engine.

MAIN CIRCULATING-PUMP ENGINES.

Each main circulating-pump will be driven by an inclined inverted cylinder direct-acting engine with 11 x 12-inch cylinder.

Each engine will be firmly bolted to a plate-and-angle bracket of approved design, riveted to the athwartship bulkhead—the bulkhead being strengthened in wake of the bracket by reverse-angles. The engine in the forward engine-room is to have its fly-wheel coupled directly to the shaft of its pump. That in the after engine-room will have a steel shaft, about 2 feet 3 inches long, interposed.

MAIN CIRCULATING-PUMP CONNECTIONS.

Each circulating-pump will be fitted with pipes and valves to draw from the sea or from the bilge at will, and will deliver into the condenser only. There will be throttle-valves, as shown in detail, in the nozzles leading from the sea and from the bilge-suction. These throttles will be so connected by levers that when one is shut the other must be open; and both will be worked by a long lever well above the floor-plates. The bilge-suction pipe will have a 12-inch screw-down non-return valve with a hand-wheel not less than 14 inches diameter on each.

The delivery-pipe from each circulating-pump to its condenser will be 17 inches diameter. A 12-inch pipe will connect the circulating-pump delivery-pipes in the two engine-rooms, with a stop-valve which can be worked from either or both engine-rooms. The discharge-pipe from each condenser will be 17 inches diameter and will be connected to the outboard-delivery valve by a slip-joint.

MAIN INJECTION-VALVES.

Each main injection-valve will be a 17⅜-inch screw stop-valve, closing against the pressure of the sea-water. It will connect with the sea by a conical steel tube through the double bottom, covered by a strainer, and with zinc protecting rings at both ends.

MAIN OUTBOARD-DELIVERY VALVES.

The main outboard-delivery valves will be of the same type and area of openings as the main injection-valves. Each valve will be bolted to the bulkhead of the adjoining reserve coal-bunker, and fitted with a zinc protecting ring. Thence a steel pipe, 18¼ inches internal diameter and ⅝ inch thick, will lead to the side of ship, discharging above the double bottom and below the protective-deck.

FEED-TANK.

There will be, in the forward engine-room, a feed-tank about 12 x 3¾ x 2⅝ feet, made of $\frac{5}{16}$-inch wrought-iron. The tank is to be stayed internally. It will have four 12 x 6 x ½-inch plates of rolled zinc suspended from the braces. The straps suspending the zinc plates, and the braces where the straps come in contact, are to be filed bright before fitting; the joints to be then well painted on the outside, or be made water-tight in other approved manner. There will be a man-hole with bolted cover at one end of tank. A glass gauge to be fitted where directed, with suitable guards, shut-off cocks, and drain-cock. The tank will have the following pipe-connections: a discharge-pipe from each hot-well; an overflow non-return valve with pipe leading to bilge, but so arranged that any water passing down it may be seen; a suction-pipe to forward feed-pumps, with valve; a suction-pipe to after feed-pumps, with valve; drain-pipes from traps, as elsewhere specified. The tank to be firmly secured in place. A drain-cock to be fitted to each end of tank.

AUXILIARY CONDENSER.

There will be in the forward engine-room an auxiliary condenser into which the auxiliary exhaust-pipe will deliver. It will be cylindrical, with a vertical axis. The casing will be 2 feet 9 inches inside diameter and 5 feet 8 inches between tube-plates. The shell will be not more than $\frac{5}{16}$ inch thick. All parts will be of the same composition as similar parts of the main condensers. There will be 721 tubes, $\frac{3}{4}$ inch diameter, secured as in main condensers, care being taken to secure them at both ends against crawling. There will be a man-hole, with relief-valve on its cover, near the bottom of the salt-water side, and a man-hole in the fresh-water channel-way. There will be a facing on the shell for attachment of the air-pump engine, and one on the channel-way for the air-pump. The condenser will be firmly bolted to the seating provided for it.

AUXILIARY AIR-PUMP.

The auxiliary air-pump will be of the vertical single-acting bucket-plunger type, of composition, with $7\frac{1}{2}$ x 7-inch cylinder. It will be bolted to the auxiliary condenser, driven direct by a special engine, and will discharge into the feed-tank.

AUXILIARY AIR-PUMP ENGINE.

The auxiliary air-pump engine will have a $6\frac{3}{4}$ x 7-inch steam-cylinder. From the piston-rod cross-head side-rods will connect to a cross-tail on the air-pump rod. The crank-shaft will be continued beyond the fly-wheel and will be cased in composition to carry the fan of the auxiliary circulating-pump. The engine-frame will be bolted to the condenser-shell and to the air-pump.

AUXILIARY CIRCULATING-PUMP.

The auxiliary circulating-pump will be of the centrifugal type, of composition, similar parts being fitted as in the main circulating-pumps. The fan will be 2 feet in diameter and

the inlet and outlet pipes 6 inches diameter. The pump will be driven direct by the auxiliary air-pump engine. The pump-casing will be bolted to the shell of the auxiliary condenser. The pump will draw water from the sea-suction valve in the forward engine-room and will discharge into the auxiliary condenser. The water leaving the condenser will go overboard through a valve on the starboard side above the double bottom. The pump is to have an air-cock on top.

BOILERS.

The boilers are to be double-ended, 14 feet 8 inches greatest diameter and 17 feet 8 inches long over heads. There will be 122 stay-tubes and 352 ordinary tubes in each end of each boiler. There will be four corrugated furnaces at each end of each boiler, 3 feet internal diameter and 6 feet 3 inches long.

BOILER MATERIAL.

All material used in the construction of the boilers, except the tubes, dogs of combustion-chamber bracing, and circulating plates, is to be open-hearth steel. The tubes are to be of wrought-iron of the best quality. All material is to be tested as elsewhere specified.

BOILER-SHELLS.

The shell of each boiler will be $1\frac{1}{32}$ inches thick, made in three rings, each ring of three plates.

COMBUSTION-CHAMBERS.

There will be four combustion-chambers in each boiler, each being common to two furnaces. They will be made of $\frac{1}{2}$-inch plates except the tube-sheets, which will be as elsewhere specified. The plates will be flanged where necessary and all parts joined by single riveting. The holes for screw stay-bolts in combustion-chambers and shells are to be drilled and tapped together in place.

BOILER-HEADS.

Each head of each boiler is to be made of three plates. The upper and lower plates will each be $\frac{7}{8}$ inch thick; the middle plates, forming the front tube-sheet, will be $1\frac{3}{16}$ inch thick. The lower plate will be flanged inwardly at each furnace, and all plates flanged inwardly at circumference.

BOILER TUBE-SHEETS.

The front tube-sheet at each end of each boiler will be as above specified. At each end there will be two back tube-sheets, the combustion-chambers for each end of each boiler being in two separate parts. The back tube-sheets will be $\frac{3}{4}$ inch thick. The tube-sheets will be drilled for the stay-tubes and plain tubes, elsewhere specified, and tapped, in place, for the stay-tubes. All tube-holes to be slightly rounded at edges. Each pair of tube-sheets must be accurately parallel.

BOILER-TUBES.

All boiler-tubes are to be of the best quality of wrought-iron, lap-welded, 6 feet 4 inches long between tube-sheets. All tubes will be $2\frac{1}{4}$ inches external diameter. The ordinary tubes will be No. 8 B. W. G., and will be swelled to $2\frac{5}{16}$ inches external diameter at the front ends. They will be expanded in tube-sheets at both ends and beaded over at combustion-chamber ends. The stay-tubes will be $\frac{1}{4}$ inch thick, upset at both ends to $2\frac{3}{8}$ inches external diameter, leaving the internal diameter as in the remainder of the tube, then swelled at the front end to $2\frac{1}{2}$ inches external diameter. They are to be threaded parallel at combustion-chamber end, and tapering at front end, to fit threads in tube-sheets. They are to be screwed into the tube-sheets to a tight joint at front end. The combustion-chamber ends will be made tight by expanding and beading. All expanding is to be done by approved tools.

BOILER-BRACING.

Each boiler will have thirty-one steel stays from head to head, all with nuts on inside and outside of heads. The five

braces adjoining the stop-valve will be $2\frac{3}{16}$ inches in diameter, with $2\frac{9}{16}$-inch threads, and the other braces 2 inches in diameter, with $2\frac{3}{8}$-inch threads. There will be at each end of each boiler six $1\frac{9}{16}$-inch stays running diagonally from the head to lower plate of combustion-chamber, with $1\frac{7}{8}$-inch threads at ends, nutted inside and outside. These nuts will bear on beveled wrought-iron washers riveted to both sides of plates. There will also be, at each end, from head to combustion-chamber, eight $1\frac{9}{16}$-inch stays, each with double and single eyes and pin-coupling near the back end. These stays will be secured to the heads in the same manner as those last described, but will be screwed into the tube-sheets, and each will have a nut in the combustion-chamber, set up on a washer riveted to tube-sheet. There will also be at each end of each boiler two diagonal $1\frac{9}{16}$-inch stays, secured to head in the same manner as above, but flattened and riveted to boiler-shells, as shown. The tops of the combustion-chambers will be stayed by bridge-braces spaced 7 inches, each with three $1\frac{1}{4}$-inch stays screwed into combustion-chamber tops and nutted. The backs and inner sides of combustion-chambers will be stayed by $1\frac{1}{4}$-inch screw-stays spaced 7 inches vertically and horizontally, screwed into the sheets of the opposite chambers and nutted. The outer sides and bottoms of combustion-chambers will be stayed in the same manner to the boiler-shells. All stays are to be made without welds.

RIVETED JOINTS.

The longitudinal joints of boiler-shells will be butted, with $\frac{3}{4}$-inch straps on inside and $\frac{7}{8}$-inch straps outside, and treble-riveted. All circumferential joints will be lapped and double-riveted. The head-plates will have lapped joints double-riveted. All joints in furnaces and combustion-chambers will be lapped and single-riveted. All rivets to be of steel. Edges of all plates to be planed. All rivet-holes to be drilled in place after bending. Hydraulic riveting to be used where possible. In parts where hydraulic riveting cannot be used

the rivet-holes are to be coned and conical rivets used. All seams to be calked on both sides in an approved manner. Longitudinal seams must break joints.

BOILER MAN-HOLES AND PLATES.

There will be in the shell of each boiler a 16 x 12-inch man-hole with the greater axis placed circumferentially. It will have a raised steel frame, flanged and riveted to shell, and flanged and faced for the cover-joint. The cover will be a flat $\frac{7}{8}$-inch steel plate, through-bolted to flange of frame, the bolts having square heads to prevent turning.

There will be in the forward head of each boiler a 16 x 12-inch man-hole. It will have a flanged steel frame similar to that above specified, but with the addition of lugs on the riveted flange, on which the nuts of the adjoining stays will be set up. The cover will be of steel, $1\frac{3}{16}$ inch thick, dished outward in hemispherical form and bolted on by a flat flange.

There will be six man-holes in each head of each boiler. Their covers will be steel, each in two thicknesses of $\frac{3}{4}$ inch each, riveted together. The outer plates must have as little clearance in the man-holes as practicable; the inner plates must have at least one-inch lap all around. The joints will be made with approved material and each plate will be secured by two wrought-iron dogs and two $1\frac{1}{8}$-inch studs with square nuts.

Each man-hole plate will have a convenient handle. All plates, dogs, and nuts to be indelibly marked to show to what holes they belong.

FURNACES.

Each furnace is to be in one piece $\frac{1}{2}$ inch thick and corrugated, 3 feet least internal diameter and 3 feet 3 inches greatest internal diameter. They must be perfectly circular in cross-section at all points. They will be riveted to flanges of front heads and will be flanged and riveted to combustion-chamber plates. The corrugations of adjacent furnaces are to alternate.

allowance for expansion. The grate-bars at sides of furnaces will be of cast-iron to fit the corrugations. The length of grate in each lower furnace will be 7 feet and in each wing-furnace 6 feet.

LAZY-BARS.

A lazy-bar with the necessary lugs will be fitted in the front of each ash-pit.

ASH-PANS.

Ash-pans of $\frac{1}{4}$-inch wrought-iron, reaching from the front of furnace-flue to bridge-wall, are to be fitted to all furnaces.

CIRCULATING-PLATES.

Each boiler will have circulating-plates fitted at each side of each nest of tubes. They will be made of wrought-iron $\frac{3}{16}$ inch thick, in sections of 1 foot wide each. Each section will be made of two pieces, with a horizontal joint secured by two $\frac{1}{2}$-inch bolts. Each section will have two clips for supporting it from the stay-tubes. The plates to be well painted all over with brown zinc and oil.

UPTAKES.

The uptakes will be made of wrought-iron, No. 7 B. W. G., built on angles, and bolted to boiler-heads and shells. They will be bolted to the lower plates of smoke-pipes, with slotted holes to allow for expansion. The uptakes are to be carried up clear of the ends of the boiler-stays. There will be a fore-and-aft division-plate in each uptake to keep the gases from the boilers separate.

UPTAKE-DOORS.

The uptake-doors will be of iron of same thickness as uptakes. Each door will have a flanged outer plate of iron, No. 12 B. W. G., held off about 1 inch by thimbles and rivets,

and the space filled with silicate cotton. The hinges and latches will be made of cast-steel. Both latches on each door will work by one lever.

UPTAKE-DAMPERS.

There is to be a damper in the uptake of each end of each boiler. It will be so fitted as to be easily worked from the fire-room, and to be securely held in any position in which it may be left. It must be tight when closed, and give a full-way passage for the gases when open. It must be so constructed that the chance of warping shall be minimized. The dampers will conform to such design as may be submitted by the contractor and approved.

UPTAKE CASINGS.

There will be a casing outside each uptake, all around, beginning just above the uptake-doors and running up to the smoke-pipe casing, to which it will be so bolted as to allow for expansion. It will be made of iron, No. 12 B. W. G., built on light angles. It will be secured to the uptake by ½-inch screw stay-bolts, nutted both sides, spaced about 2 feet apart. It will be about 3 inches distant from the uptake at bottom, the space increasing until the smoke-pipe casing is met. There will, in addition, be an outer casing over the fronts of uptakes, beginning at the bottom and running up to the protective-deck, to which it will be secured in such a manner as to allow for expansion. It will be built on T-iron frames and must be air-tight. It will have at bottom, over each furnace, an easily-worked sliding-shutter, 6 x 4 inches, to admit air when desired.

UPTAKE CASING-DOORS.

The uptake casing above specified will have single-plate doors, not less than ¼ inch thick, in front of the uptake-doors. They will have cast-steel hinges and latches, and must be so fitted as to be air-tight when closed. They must be of sufficient size to allow the corresponding uptake-doors to be opened to their full extent.

SMOKE-PIPES.

There will be two smoke-pipes, one for each pair of boilers. They will begin just above the protective-deck and follow the shape of the uptakes until the parts coming from the opposite ends of each boiler join; thence each pipe will continue in wedge-form to a point just below the upper deck, where it will be rectangular in cross-section, 7 feet 7 inches by 5 feet 7 inches. In the next six feet it will gradually merge into an oval cross-section with the same diameters as noted above, and will keep this form to the top, about 60 feet above the grate-bars of the wing-furnaces. The fore-and-aft division-plate of each uptake will be continued in the smoke-pipe up to about the level of the main-deck. There will also be an athwartship division-plate up to the top of the wedge-shaped part. The pipes will be made of wrought-iron, No. 7 B. W. G. The lower part of each pipe will be stiffened by angle-irons. Above the beginning of the oval part there will be internal cross-stays of $1\frac{1}{8}$-inch iron, with T-heads, riveted to angles. Each pipe will be finished at the top by an angle-iron, to which the stay-shackles will be secured, and by a hood covering the casing, to which will be secured shackles for slinging painters. There will be a ladder on the outside of each pipe (not inside, as shown), reaching to the top, on the forward part. Each pipe will be strongly stayed by guys and turnbuckles of approved dimensions and pattern. All joints will be butted and strapped. The pipes will be supported in an approved manner, all the work being done by the contractor for the machinery.

SMOKE-PIPE CASINGS.

From its junction with the uptakes to about six inches below the hood at top, each smoke-pipe will be surrounded by a casing which will leave an annular space of 6 inches. The casing will be made of iron, No. 12 B. W. G., and strengthened by angle-iron. It will be butted and strapped, flush-riveted on the outside. It will be stayed to the pipe where necessary, and will be finished with a half-round iron at top.

There will be doors through this casing and through smoke-pipe about on a level with the main-deck. Above the smoke-pipe hatch an oval casing, about 11 feet 7 inches by 9 feet 7 inches, will extend for about 5 feet, and be finished by half-round iron. About one foot above this there will be a hood, carried by the casing before mentioned.

SMOKE-PIPE COVERS.

Each smoke-pipe will be fitted with a cover of wrought-iron, No. 12 B. W. G., made in four parts and bolted together. Each cover will have eight legs to support it about 6 inches above the top of the smoke-pipe, to which each leg will be secured by a tap-bolt. Each part of each cover will have shackles or eyes for handling. The covers to be finished at edges by half-round iron. Each cover to have conveniences provided for stowing it when not in use.

BOILER-SADDLES.

Each boiler will rest in three saddles, which will be built in and form part of the hull. It will be secured to the saddles by bolts of approved dimensions, screwed into the boiler-shell with heads inside. The bolts are to pass through oval holes in the saddles to allow for expansion, and will have washers and nuts on the under side.

BOILER ATTACHMENTS.

Each boiler will have the following attachments, viz:

One steam stop-valve;
One dry-pipe;
One main feed check-valve with internal pipe;
One auxiliary feed check-valve with internal pipe;
One surface blow-valve with internal pipe;
One bottom blow-valve with internal pipe;
Three safety-valves;
Two steam-gauges;
Three glass water-gauges;
Eight gauge-cocks;

Two sentinel-valves;
One salinometer-pot;
Two drain-cocks;
One air-cock;
Two hydrokineters or equivalent;
One cock with thread for the attachment of a syringe.

All external fittings will be of composition unless otherwise directed. No fittings are to be screwed into the boiler-plates, but will be flanged and through-bolted, or attached in other approved manner. All cocks, valves, and pipes will have spigots, or nipples, passing through the boiler-plates. All internal pipes are to be of brass, No. 14 B. W. G., and must touch the plates nowhere except where they connect with their external fittings. The internal feed and blow-pipes will be expanded in the holes in boiler-shells to fit the nipples on their valves, and they will be supported where necessary in an approved manner. The stems of all valves on boilers are to have outside screw-threads. The internal feed and blow-pipes are to be arranged to come between the corrugations of furnaces.

BOILER STOP-VALVES.

Each stop-valve will be bolted on the afterhead of its boiler, outboard of the center. It will be self-acting, 11 inches diameter, with its spindle horizontal, pointing outboard and about 25° abaft the beam. The axis of its outlet-nozzle will be horizontal, pointing aft and inboard. There will be bolted to this nozzle a composition elbow with a stuffing-box, pointing horizontally inboard, for the attachment of steam-pipe. There will be a bracket cast on each valve-chest, to be bolted to boiler-head for additional stiffness.

The valve-discs, spindles, guides, yokes, hand-wheels, and bonnets will be as per drawings.

DRY-PIPES.

Each boiler will have a brass dry-pipe, No. 14 B. W. G., tapering from 10¾ inches to 8 inches internal diameter, with closed end. It will be placed as high as practicable and suit-

ably supported. It will have slits at the top, $\frac{1}{16}$ inch wide, with a collective area of 180 square inches.

Its attachment to boiler will be changed from that shown in drawing to the following to prevent danger of a "water-hammer:" Riveted to the inside of the after head of the boiler, with a flange corresponding in shape to the flange of the stop-valve, will be a cast-steel nozzle, about 8 inches long, with a circular flange to which the open end of the dry-pipe will be bolted. The flanges and walls of this nozzle to be $\frac{3}{4}$ inch thick.

FEED CHECK-VALVES.

The main and auxiliary check-valves will each be $2\frac{3}{4}$ inches in diameter. They will be fixed on the after ends of the forward boilers and the forward ends of the after boilers.

BOTTOM BLOW-VALVES.

The bottom blow-valves will be $2\frac{1}{4}$ inches diameter, placed at ends of boilers opposite the check-valve ends, but with approved gear for working from the fire-rooms where the feed-pumps are situated. The internal pipes will lead to bottoms of boilers.

SURFACE BLOW-VALVES.

The surface blow-valves will be $2\frac{1}{4}$ inches diameter, and placed at same ends of boilers as the bottom blow-valves, but worked from the opposite ends in an approved manner. Each internal pipe will lead to a dish about one inch above the highest heating surface.

SAFETY-VALVES.

Each boiler is to have three $5\frac{1}{4}$-inch spring safety-valves in one case, with spindles horizontal, bolted to tops of boilers. Each set of valves is to be fitted with approved gear for lifting from the main-deck as well as from fire-rooms, the gears to work independently of each other. The valves are to be lifted from the forward fire-room of each compartment. The toes for lifting the valves will be stepped, so that the valves

will be lifted in succession. All joints in the lifting-gear to be composition-bushed. Each valve is to be set at 138 pounds per square inch, and is to be furnished with washers for the reduction of pressure to 93 pounds by decrements of 5 pounds. Each washer is to be marked to show its place. A drain-pipe will be attached to each safety-valve case at the lowest part, and will lead to the bilge.

SENTINEL-VALVES.

Each boiler will have, upon each end, a sentinel-valve of $\frac{1}{2}$ square inch area. It will have a sliding weight on a notched lever graduated to 150 pounds pressure.

BOILER STEAM-GAUGES.

There will be two Lane's improved spring steam-gauges on each boiler with $8\frac{1}{2}$-inch dials. The gauge on the feeding end of each boiler will be graduated to 230 pounds and that on the other end to 160 pounds. Each gauge is to have an independent connection to its boiler, and will be fitted with a three-way cock and a coupling for attachment of a test-gauge.

BOILER WATER-GAUGES.

Each main boiler will have three glass water-gauges of approved pattern, two on the feeding end and one at the other end. Each gauge will be placed at the side of the boiler and will have $1\frac{1}{2}$-inch pipes leading to top and to near bottom of boiler, with a valve in each close to boiler. The shut-off and blow-out cocks are each to have at least $\frac{1}{2}$-inch clear opening, and are to be packed cocks, with levers and rods for working from fire-room. The glasses are to be about 16 inches in exposed length, with the lowest exposed part about one inch below the highest heating surface. The glasses to be well protected. A brass index-plate, with letters and arrows cast in relief, is to be fixed close to each gauge-glass to show the height of the top of combustion-chamber. The blow-out cocks will have drain-pipes leading to bilge, with union joints.

GAUGE-COCKS.

There will be four asbestos-packed gauge-cocks of approved pattern on each end of each boiler, with rods and levers for working from fire-room. Each cock is to have an independent attachment to the boiler. They will be spaced about 6 inches vertically, the lowest one being about 4 inches below the highest heating surface. Each set of cocks to have a drip-pan and a drain-pipe leading to bilge.

SALINOMETER-POTS.

There will be a salinometer-pot of approved pattern connected to each boiler, and placed in the feeding fire-room where directed.

BOILER DRAIN-COCKS.

Each main boiler will have at each end a $1\frac{1}{4}$-inch asbestos-packed drain-cock of approved pattern.

BOILER AIR-COCKS.

Each main boiler will have a $\frac{1}{2}$-inch air-cock at its highest part, with a $\frac{3}{8}$-inch copper pipe leading to bilge.

HYDROKINETERS.

There will be fitted to each main boiler two Weir's hydrokineters, or other approved devices, for circulating the water in the boiler while raising steam. Each of these will be fitted where directed, and will have a stop-valve close to boiler. They will take steam from the auxiliary steam-pipe, with stop-valve in fire-room.

ZINC BOILER-PROTECTORS.

Each main boiler will be fitted with seventy-two rolled zinc plates 12 x 6 x $\frac{1}{2}$ inch. Each plate will be bolted to a wrought-iron strap, which will be clamped to the stays. Each strap will be filed bright where in contact with zinc and stay, each stay being also filed bright at contact point. After being bolted in place the outside of the joints will be made water-tight by paint or approved cement.

BOILER CLOTHING.

After the boilers are tested and painted they will be covered on tops and sides, and on ends where required, by $\frac{1}{16}$-inch galvanized wrought-iron plates, lapped and bolted to angles, which will be held in place by $\frac{1}{2}$-inch bolts tapped part way into the boiler-plates. There will be a space of not less than 1 inch between boilers and covers, which will be filled with approved incombustible non-conducting material securely held in place.

AIR-TIGHT FIRE-ROOMS.

Air-tight supplemental bulkheads of wrought-iron, No. 12 B. W. G., will be fitted to reduce the space to be kept under air-pressure. Allowance will be made for expansion of plates and boilers. Openings are to be provided where required, with suitable means of closing them. All permanent and temporary joints must be perfectly air-tight.

BLOWERS.

There will be eight blowers of approved pattern, two in each fire-room as shown. They will take air from branches of the fire-room ventilators and will deliver directly into fire-rooms. Doors will be provided for the purpose of getting at the bearings of fan-shaft, as well as means for properly lubricating them from fire-room without opening the doors. The bearings to be of anti-friction metal in composition. Each blower must be capable of continuously furnishing to the fires at least 20,000 cubic feet of air per minute under a pressure of 4 inches of water.

BLOWING-ENGINES.

Each blower will be driven direct by a three-cylinder engine of approved pattern, of sufficient power to run the blowers at full speed with steam of 100 pounds pressure. The throttle-valve in the steam-pipe of each blowing-engine will be arranged to be worked from the fire-room floor, with suitable index to show how much open.

AIR-PRESSURE GAUGES.

An approved gauge will be fitted in each fire-room to show the excess of air-pressure over the pressure of the open atmosphere. A portable gauge will also be supplied to each fire-room, with conveniences for connecting it to the furnaces, uptakes, and wherever desired to measure the air-pressure as compared with the pressure in the fire-rooms.

All these gauges are to indicate pressures in "inches of water."

FIRE-TOOL RACKS.

Racks will be fitted in each fire-room, in convenient places, for holding all necessary fire-tools.

MAIN FEED-PUMPS.

There will be in the after fire-room of the forward boiler compartment, and in the forward fire-room of the after boiler compartment, a vertical duplex pump of approved pattern, each pump-cylinder having a stroke displacement of 254 cubic inches. The area of the steam-pistons will be 2¼ times that of the pump-pistons. The valves will be metallic, of such pattern as may be approved. Each main feed-pump will draw water from the sea and from the feed-tank, and will deliver into main feed-pipe only.

AUXILIARY FEED-PUMPS.

There will be in each of the two feeding fire-rooms an auxiliary feed-pump, which will be in construction a duplicate of the main feed-pump. It will draw water from the sea, feed-tank, and bottoms of condensers, and will deliver into the auxiliary feed-pipe and the fire-room fire-main.

ASH-HOISTS.

Each fire-room ventiliator will be fitted at the bottom with an air-lock, to be used when ashes are being hoisted while forced draught is used. Each ventilator will be fitted with

the necessary sheaves, whip, and appliances for handling ash-buckets complete. There will be secured to the athwartship bulkhead of each fire-room an ash-hoisting engine of approved design, of sufficient power to hoist 150 pounds from the fire-room floor to the upper deck in five seconds with steam of 60 pounds pressure. Each engine will have reversing-gear worked from the upper deck in an approved manner. It will also have an approved adjustable safety-gear to prevent overwinding and to stop the engine when the ash-bucket reaches the fire-room floor.

ASH-DUMPS.

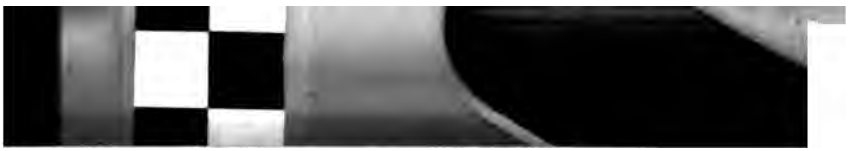
From each ash-hoist, on the upper deck, permanent overhead rails, suitably supported, will lead to the nearest ash-chutes on each side of the ship. Each of these will be fitted with a traveler of approved design, with all necessary appliances for carrying the ash-buckets. At the top of each ash-chute a dumping-hopper of approved design will be fitted, so arranged as to fold up out of the way when not in use. The ash-buckets are to be balanced dump-buckets, with all necessary gear complete. All the ash-hoisting and dumping-gear is to be such that the buckets will not have to be lifted by hand.

STEAM TUBE-CLEANERS.

A steam tube-cleaner, as shown, will be fitted in each fire-room. Steam will be taken from the auxiliary steam-pipe by a small stop-valve worked by a lever with a light brass chain leading down into fire-room. Sufficient length of steam-hose will be provided to easily reach all the tubes.

FIRE-PUMPS.

There will be in each engine-room a double pump of same type and size as the main feed-pumps. Each pump will have suctions to the sea and engine-room bilge, and will deliver overboard and into the fire-main and the engine-room water-service pipes. These pumps will be secured to brackets on



the athwartship bulkhead in forward engine-room and on side of ship in after engine-room. Each pump will have an adjustable air-valve in its suction-pipe.

BILGE-PUMPS.

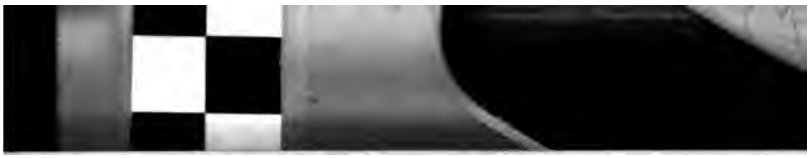
There will be in each engine-room a vertical duplex pump, with water-cylinders of 110 cubic inches stroke displacement each. The area of the steam-pistons will be 1¾ times the area of the pump-pistons. Each of these pumps will have suctions from the sea, the engine-room bilge, the ship's drainage system, and the boilers. The pump in the forward fire-room will also have a suction from the double-bottom valve-boxes. Each pump will deliver into the fire-main and overboard. They will be placed as near as possible to the fire-pumps, and will be supported in the same manner.

HAND-PUMP.

There will be a hand-pump with plunger of 6 inches diameter and 6 inches stroke, as per detail drawings, fitted in the forward engine-room. It will have an additional plunger of 3 inches diameter, with stuffing-box and gland, for testing boilers. The pump will have suctions from sea, boilers, bilge, and crank-pit, and will deliver overboard, into fire-main, and into auxiliary feed-pipes. Proper means will be provided for stowing the hand-brakes.

TURNING-ENGINES AND GEAR.

There is to be fitted in each engine-room a double vertical-cylinder engine with overhead-cranks, having 7 by 7-inch cylinders, driving by worm and bevel-gearing a worm which may be made at will to mesh with a worm-wheel on the propelling-shaft. The engines and the brackets of all the bearings will be secured to plate-and-angle facings riveted to the after bulkheads of engine-rooms. Each principal worm-shaft will be carried at one end by a pivoted thrust-bearing, being driven at that end by a flexible coupling. At the other end



it will be carried by a bearing moving in vertical guides and suspended from the shorter arm of a bell-crank. The longer arm of the bell-crank will be weighted to hold the worm out of gear when thrown out. All the worm-shafts are to be of forged-steel. One end of the principal worm-shaft will be squared, and will be be fitted with a ratchet-wrench for turning the gear by hand. Each turning-engine will be reversible by means of a change-valve with hand-lever.

The turning-wheels will be of cast-steel with cut teeth, each wheel being made in two parts, bolted together on the shaft and keyed.

DISTILLING APPARATUS.

The distilling apparatus will consist of two evaporators and two distillers, with their attachments, having a combined capacity of 5,000 gallons of potable water per 24 hours. The evaporators will be made with shells of steel, heads and flanges of cast-iron, and coils of copper; adapted to a working pressure of 20 pounds per square inch. They will be fitted and lagged, and will each be fitted with a safety-valve, steam-gauge, glass water-gauge, gauge-cocks, salinometer-pot, and blow-valve. They will take steam from the auxiliary steam-pipe, and will be fitted with automatic traps and drain-pipes leading to feed-tanks. A direct-acting pump of approved pattern and size will be fitted for feeding the evaporators. The distillers will be made with shells of sheet-brass, flanges and heads of composition, and coils of copper or brass, thoroughly tinned on both sides. Each coil must have separate steam and drain-valves. The steam-pipe of each distiller will be fitted with an air-injector, which will be supplied by a pipe leading from above the awnings. A filter of approved design will be fitted to each distiller, with pipes leading to the fresh-water tanks.

There will be a pump of approved design and sufficient capacity to circulate water through the distillers. It will draw water from a special sea-valve placed where directed. The water after leaving the distillers will lead forward by a

proper pipe with connections for flushing the crew's water-closets, and with branches leading to the officers' water-closets. A bye-pass pipe will be provided, so that water may pass to the water-closets when the distillers are shut off.

The evaporators and distillers will be so fitted that their coils can be easily removed for repairs. There must be no internal joints in the coils of either evaporators or distillers.

MAIN STEAM-PIPES.

A 10¾-inch pipe will connect the two boiler stop-valves in each boiler compartment, that in the after fire-room being curved aft to clear the auxiliary boiler uptake. From the cross-pipe in the after fire-room a 15-inch pipe will lead to the after engine-room. In the after engine-room it will pass over the main exhaust-pipe and connect with a separator just outside the throttle-valve.

From the cross-pipe in the forward boiler compartment a 15-inch pipe will curve to starboard, coming out into the after-boiler compartment pointing aft, and as near the fore-and-aft bulkhead as practicable; it will lead straight through the after-boiler compartment and into the forward engine-room about 3 feet; thence it will turn inboard and run to a separator close to throttle-valve. There will be a stop-valve in each 15-inch pipe close to its connection to the cross-pipe, worked from fire-room or deck at will. An athwartship 15-inch pipe close to forward bulkhead of forward engine-room, will connect the two fore-and-aft pipes. Immediately abaft this pipe there will be, in the pipe leading to each engine, a stop-valve with gear for working from either engine-room at will.

AUXILIARY STEAM-PIPES.

An auxiliary steam-pipe will extend through engine and boiler compartments with branches to all auxiliary engines. Its principal connection with the main steam-pipe will be in the cross-pipe in forward engine-room. There will also be a connection with the main steam-pipe in each of the other com-

partments, of sufficient size to supply all auxiliary engines in that compartment. The auxiliary steam-pipe will also connect with an auxiliary stop-valve on each of the boilers in the forward compartment. There will be a stop-valve on each side of each water-tight bulkhead. Branches will connect with the whistle, the radiators, and the evaporators. Branches will also be led to the windlass, the steering-engine, engineer's workshop, the dynamo-engines, the ventilating-fan engines, and the machinery in torpedo-rooms; but the connections will be made by those who furnish the machinery in those places. Stop-valves will be fitted wherever necessary. There will be a steam-gauge in brass case, with about 6-inch dial, attached to the auxiliary steam-pipe in each engine-room and each boiler compartment; also one at windlass and one at steering-engine.

BLEEDER-PIPES.

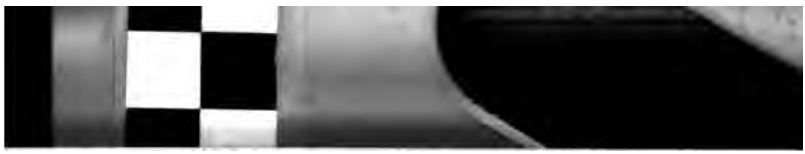
A 5-inch branch from the main steam-pipe in each engine-room will lead to the condenser, with a stop-valve operated from the working-platform.

AUXILIARY EXHAUST-PIPES.

An auxiliary exhaust-pipe will be fitted, with branches leading to all auxiliary engines. It will have valves to direct the exhaust-steam into the auxiliary condenser or the auxiliary escape-pipe at will. Branches will be led to the dynamo-engines, ventilating-fan engines, torpedo machinery, windlass, steering-engine, and workshop engines, but not connected.

ESCAPE-PIPES.

There will be an 11-inch escape-pipe abaft each smoke-pipe, extending to top, finished and secured in an approved manner. Each pipe will have branches leading to all the safety-valves in its boiler compartment. There will also be abaft the after smoke-pipe, fitted the same as the others, a 10-inch escape-pipe, connected to the auxiliary exhaust-pipe as above specified. Each of the safety-valve escape-pipes will be fitted with an approved muffler.



ENGINE-ROOM WATER SERVICE.

There will be in each engine-room a 2-inch pipe, connected with the sea-suction valve and with the fire-pump delivery, with branches leading to the different parts of the engine as follows: branches to standards on top of main bearing oil-boxes; a branch to each link-block guide; a branch to each cross-head slide; a branch to each telescopic lubricator of cross-heads; a branch to each centrifugal oiler of crank-pins; a branch to each circulating-pump engine. The standards on the main bearing oil-boxes will have water connections to each main bearing, crank-pin, and eccentric, with sprays, as shown. Each branch-pipe and each spray will have a separate valve. The water service in the after engine-room will also have a branch to the water-box on each thrust-bearing and one to each line-shaft and thrust-shaft pillow-block. All the water-service pipes and fittings above the floors are to be of polished brass. The main pipe below the floors will be of seamless drawn copper. The water-service pipes of the two engine-rooms are to be connected with each other by a pipe and valve.

SEA-SUCTION PIPES.

A pipe will lead from the sea-suction valve in the after engine-room to the fire and bilge-pumps; and one in the forward engine-room to the fire and bilge-pumps, with a branch to the hand-pump and a pipe to the auxiliary circulating-pump. In each boiler compartment pipes will lead from the sea-suction valves to the main and auxiliary feed-pumps. A pipe will also lead from a sea-valve, fitted where directed, to the distiller circulating-pump. Each of these pipes will be of at least the same bore as the nozzle on the pump with which it connects. Each sea-suction will be controlled by a cock or valve which will not permit sea-water to enter any of the suction-pipes.

FEED-TANK SUCTION-PIPES.

From the feed-tank a suction-pipe will lead to the main and auxiliary feed-pumps in the after boiler compartment. A

PIPE CLOTHING.

All steam and exhaust-pipes, the separators, and all steam-valves are to be clothed in an approved manner with a satisfactory incombustible non-conducting material, covered with canvas in double thickness, well painted. The canvas covering of steam-pipes to be secured to bulkheads where the pipes pass through them. The main steam-pipes in engine-rooms and the main exhaust-pipes and the separators are also to be covered with black-walnut lagging, in sections, with brass bands. The main steam-pipe from the forward boilers to the forward engines, where it passes through the after boiler compartment, will, in addition to the covering above specified, be inclosed in a water-tight casing of copper; likewise the steam-pipe to after engines, from the after bulkhead of forward engine-room to its stop-valve in forward part of forward engine-room; also the cross-pipe in forward engine-room.

PIPES THROUGH COAL-BUNKERS.

All pipes passing through coal-bunkers will be protected by sheet-iron casings, made in sections and easily removable for repairs. Pipes must not be led under openings of coal-chutes.

PIPES THROUGH BULKHEADS AND DECKS.

All pipes passing through water-tight bulkheads or decks will be made water-tight by stuffing-boxes, flanges, or other approved means. Pipes must not be led in such a way that the angles or tees of bulkheads have to be cut. Holes through wooden decks, where pipes pass through, are to have brass or copper thimbles, made water-tight, and extending at least 3 inches above the deck.

MATERIAL AND FITTING OF PIPES.

All pipes, except the lower parts of bilge-suction pipes, or where otherwise specified, are to be of copper. All feed and blow-pipes and all bilge-suction pipes, except the lower parts,

and all steam-pipes less than 3 inches diameter, are to be of seamless-drawn copper. All copper pipes not seamless-drawn are to be brazed. All copper pipes are to have composition flanges riveted on, calked, and brazed. All flanges are to be faced and grooved, and joints are to be made with red lead without sheet-lead or canvas. All composition flanges below the floor-plates are to be connected by Tobin's-metal bolts and nuts. All copper pipes in bilges are to be well painted and covered with waterproof canvas, and must not rest in contact with any of the iron or steel work of the vessel. All bends in copper pipes are to be made one gauge thicker than straight parts. All copper pipe T-pieces and fittings are to be made of composition. Expansion joints are to be fitted where shown in drawings, and elsewhere as may be needed.

Slip-joints are to have stop-bolts and flanges where directed. All steam and exhaust-pipes, where possible, are to be made $\frac{1}{4}$ inch short in every 12 feet of length, and then drawn to place, to allow for expansion. The lower parts of bilge-suction pipes are to be made of galvanized iron.

The after length of each main steam-pipe is to be fitted with a ring-piece between the flanges, to admit of a blank flange being inserted for testing the boilers and pipes independently of the engines; suitable blank flanges are to be supplied.

THICKNESS OF PIPES.

The thickness of metal in the principal pipes will be as follows, by B. W. G.:

Steam-pipes of 15 inches bore	No. 3
Steam-pipes of 10¾ inches bore	No. 5
Steam-pipes of 5 inches bore	No. 9
Steam-pipes of 4 inches bore	No. 10
Steam-pipes of 3 inches bore	No. 11
H. P. exhaust to I. P. cylinder	No. 7
I. P. exhaust to L. P. cylinder	No. 7
L. P. exhaust to condenser	No. 7
Circulating-pump suction and discharge pipe	No. 5
Bilge-injection pipes	No. 11

Air-pump discharge to feed-tank	No. 11
Feed-pump suction-pipes	No. 13
Feed-pump discharge-pipes	No. 10
Blow-pipes	No. 9
Auxiliary exhaust-pipes	No. 14
Escape-pipes	No. 13
Dry-pipes	No. 14
Connections to fire-main	No. 10
Galvanized wrought-iron bilge-suction pipes	No. 7

All other pipes to be of such thickness as may be approved.

DRAIN-PIPES AND TRAPS.

All places where condensed steam can accumulate will be provided with drain-pipes and cocks or valves of ample size, and with approved automatic traps which will discharge into feed-tanks or condensers, or as directed. All traps are to have bye-pass pipes and valves for convenience of overhauling. The lowest parts of all water-pipes and all pump-cylinders and channel-ways are to have drain-cocks, with pipes where required.

AUXILIARY ENGINE STOP-VALVES.

Each auxiliary engine will have stop-valves in both steam and exhaust-pipes as close as possible to the cylinders, and all pumps will have screw check-valves in both suction and delivery-pipes close to pumps. Exhaust stop-valves are to be straight-way where practicable.

PUMP RELIEF-VALVES.

All feed, bilge, and fire-pumps will have adjustable spring relief-valves of approved design, connecting the delivery and suction passages.

SEA-VALVES.

There will be, in the various compartments, sea-valves as follows:

In after engine-room: A 5⅜-inch sea-suction valve with a 4½-inch nozzle for pump-suctions and a 2-inch nozzle for en-

gine-room water-service; to be a screw stop-valve, and to be attached to ship above the double bottom;

A double valve-box with two screw non-return valves, one $3\frac{3}{8}$ inches for bilge-pump discharge and one $3\frac{7}{8}$ inches for fire-pump discharge; also to have a $1\frac{5}{8}$-inch non-return valve attached for trap-discharge;

A main injection-valve and a main outboard-delivery valve, as before specified.

In forward engine-room: An 8-inch sea-suction valve with a $7\frac{1}{4}$-inch pivoted throttle-valve with nozzle for auxiliary circulating-pump suction; also with a $4\frac{1}{2}$-inch nozzle for bilge and fire-pump suctions, and a 2-inch nozzle for engine-room water-service; to be a screw stop-valve, with pipe passing through the double bottom;

A valve-box with a $6\frac{3}{8}$-inch screw non-return valve for auxiliary circulating-pump discharge; a $3\frac{3}{8}$-inch screw non-return valve for bilge-pump discharge; a $3\frac{7}{8}$-inch screw non-return valve for fire-pump discharge; a $2\frac{1}{4}$-inch screw-valve with rubber face for hand-pump discharge, and a $1\frac{5}{8}$-inch non-return valve for trap discharge;

A main injection-valve and a main outboard-delivery valve, as elsewhere specified.

In each boiler compartment: A $3\frac{7}{8}$-inch sea-suction valve with two $3\frac{1}{2}$-inch nozzles for feed-pump connections; to be a screw stop-valve connected to bottom of ship through the double bottom;

A $3\frac{3}{16}$-inch Kingston valve, connected to the blow-pipe by a 3-inch nozzle, its casing to be connected to outer skin of bottom of ship and to pass through a cast-iron stuffing-box on inner skin.

There will also be a sea-suction valve for the distiller circulating-pump, placed where directed. The Kingston valves are to have their spindles cast on, and are to be tested by tensile strain of half a ton to every square inch of the area of the valves. All sea-suction valves are to have gratings on the outside of the ship. No waste water is to be delivered above the water-line.

ATTACHMENT OF VALVES TO HULL.

Steel strengthening-rings will be riveted to plating of hull around the openings for all sea-valves. The valve-flanges will be bolted to these rings by naval-brass studs, care being taken not to drill the holes entirely through the rings. Attachments will be made to the inner skin as may be approved. A zinc protecting-ring will be fitted in each opening in outer skin, and at the openings in inner skin for the main injection and outboard-delivery valves.

PLUGS FOR DISCHARGE-OPENINGS.

A composition plug with india-rubber joint is to be fitted to each discharge-opening; to be put in or taken out by a lever on the ship's side above the water-line. The outriggers on the ship's side are to be complete, with all levers and gear.

BILGE AND DOUBLE-BOTTOM VALVE-BOXES.

The bilge and double-bottom suction valve-boxes and valves are to be supplied by the engine contractors, who will also connect them with the pumps; but the connections to them from the bilge-drains and from the forward and after compartments will be made by the hull contractors. There is to be a separate valve for each suction, and they are all to be plainly marked to show their uses.

COCKS AND VALVES.

All cocks and valves and their fittings, unless otherwise specified, are to be made of composition. All hand-wheels are to be of finished brass. All cocks communicating with vacuum spaces are to have bottoms of shells cast in and to have packed plugs. All cocks over one inch in diameter are to have packed plugs. Valves of approved pattern are to be supplied wherever necessary to complete the various pipe systems, whether shown in drawings or not. Cocks and

valves may, where directed, have, in lieu of wheels or permanent handles, removable box or socket-wrenches, marked and stowed in convenient racks. All valve-spindles are to turn right-handed to close. All cocks and valves beneath the floor-plates are to have their wheels or handles above the floor-plates, except where otherwise specified, in easily accessible positions. All valves must be so fitted as to be easily ground in, and be fitted where necessary with grinding-in guides and handles.

LABELS ON COCKS AND VALVES.

All cocks are to have engraved brass plates to show their uses and to indicate whether open or shut. All valves, except such as may be otherwise directed, are to have similarly engraved plates to show their uses, or have the same plainly engraved on hand-wheels. All engraving to be deep and to be filled in with black cement. All main steam-stop valves are to have indices to show to what extent they are opened.

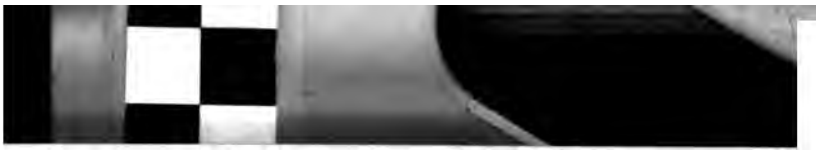
WHISTLE.

An approved polished brass steam-whistle, with bell of about 8 inches diameter, is to be placed forward of the forward smoke-pipe, well above the level of the awnings, and connected to the auxiliary steam-pipe by a pipe having a stop-valve at its lower end and a working-valve at the upper end. The pipe to have an expansion-joint at lower end.

RADIATORS.

Radiators or heating-coils as may be directed, of approved patterns, will be furnished, fitted, and connected, with superficial areas as follows:

In the commanding officer's cabin, four of 20 sq. feet each;
In the commanding officer's bath-room, one of 2 square feet;
In the commanding officer's office, one of 2 square feet;
In the ward-room, four of 20 square feet each;
In the steerage, two of 15 square feet each;
In the steerage country, two of 15 square feet each;



In the crew's quarters on the berth-deck, an aggregate of 350 square feet, divided as may be directed;

In the sick-bay, two of 15 square feet each;

Under the forecastle, two of 20 square feet each;

In the pilot-house, one of 6 square feet;

In the chart-house, one of 4 square feet.

Each radiator or coil of more than 6 square feet surface is to be divided into two parts, and each of more than 20 square feet into three or more parts—each with its separate steam and drain-valves. The radiators in the crew's quarters will have the valve-stems squared and fitted with removable keys. The steam and drain-pipes are to be of seamless-drawn brass, iron pipe size, suitably connected by composition fittings in a manner that will enable them to be easily taken down for repairs. All union-joints to be coned or to have corrugated copper washers. All holes through decks and bulkheads to be thimbled with brass. Steam and drain-pipes to be clothed where near wood-work. The steam-pipes will connect with the auxiliary steam-pipe where directed, and will be fitted with adjustable reducing-valves. The drain-pipe of each circuit will have an approved steam-trap discharging into feed-tank, and elsewhere as may be directed.

SHAFTS THROUGH BULKHEADS.

All shafts passing through water-tight bulkheads will be fitted with stuffing-boxes.

FLOOR-PLATES.

The engine-rooms, fire-rooms, and connecting passages are to be floored with wrought-iron plates ¼ inch thick, with neatly matched flat-topped corrugations running fore-and-aft. The plates are to be of convenient size and easily removable. They will rest on proper ledges, of angle or T-iron, and will have drain-holes where necessary. Platforms will be provided for getting at all parts of the main and auxiliary engines and boilers. These platforms, where placed over moving machinery, will be fitted the same as the lower floors. In other places they

will be made of iron rods $\frac{5}{8}$ inch square, placed $\frac{3}{4}$ inch apart. The fire-room floors will be so arranged as to permit all furnaces to be easily fired, without interfering with getting out coal.

LADDERS.

Ladders will be fitted wherever necessary for reaching the engine-rooms and fire-rooms from deck, and for reaching the various platforms, passages, and parts of machinery. The engine-room ladders will be made with plate-iron sides and light cast-iron treads with corrugated tops. The fire-room ladders will be made with plate sides and double-square bar-treads. All ladders will be so fitted as to be easily removable where required, and will be jointed and hinged, with necessary fastenings and gear, where they have to be moved when closing hatches. Light iron ladders will be fitted to and through one ventilator in each engine-room and each fire-room as means of egress when the battle-hatches are closed.

HAND-RAILS.

Finished brass hand-rails, with finished wrought-iron stanchions, easily removable where required, will be fitted to all ladders and platforms and around all moving parts of machinery and along bulkheads and passage-ways.

WORKING-PLATFORMS.

There is to be a working-platform over each high-pressure cylinder, fitted with plates the same as for lower floors. The space between cylinder and platform is to be filled in, where practicable, with non-conducting material. The counter, revolution-indicators, clock, gauges, telegraph-dials, and other engine-room fittings are to be so placed near the working platform as to be in full view while working the engines. Speaking-tube mouth-pieces and telegraph-levers to be conveniently placed.

WORKING-LEVERS AND GEAR.

There will be at each working-platform the following hand-gear, viz:

One reversing-lever;
Three starting-valve levers;
Two cylinder drain-cock levers;
Hand reversing-wheel;
Engine stop-valve hand-wheel;
Bleeder-valve hand-wheel;
Reversing-engine stop-valve hand-wheel;
Starting-valve stop-valve hand-wheel;
Hand-wheel for lifting intermediate valve-chest relief-valve.

The levers for working the starting-valves and drain-cocks are to have spring-catches of "locomotive pattern." All hand-gear to be suitably engraved to show its use, or otherwise plainly marked in an approved manner.

ENGINE-ROOM INSTRUMENTS.

Each engine-room will be fitted with the following, in full view of the working-platform and properly lighted, viz:

One Lane's improved spring steam-gauge, connected to the main steam-pipe;

One Lane's improved spring steam-gauge, connected to the high-pressure exhaust-pipe;

One Lane's improved spring compound-gauge, connected to the intermediate exhaust-pipe;

One Lane's improved spring compound-gauge, connected to the main condenser;

One eight-day clock with second-hand;

One continuous rotary counter with positive motion, to register from 1 to 1,000,000;

Two revolution-indicators, showing on suitable dials the speed of both screw-engines;

One telegraph-dial.

There will also be in each engine-room the following instruments, attached directly to the various parts of the machinery:

One hot-well thermometer, to be connected to the hot-well discharge-pipe;

One injection-water thermometer;

One discharge-water thermometer;

One steam-thermometer in main steam-pipe;

One mercurial vacuum-gauge on main condenser;

One counter or revolution-indicator on the main circulating-pump.

Each working-platform will be fitted with telegraph and speaking-tubes, leading to engine-rooms, fire-rooms, wheel-house, conning-tower, bridge, and where directed.

Each engine-room will be furnished with six Thompson indicators of standard size, of the latest pattern made by the American Steam Gauge Company; two to have, each, a spring of 80 pounds to the inch and one of 64 pounds; two to have, each, a spring of 40 pounds to the inch and one of 32 pounds; each of the other two indicators to have a spring of 20 pounds to the inch and one of 16 pounds. All indicators to be nickel-plated and to be complete with all attachments. One extra cock-attachment to be furnished with each indicator. Each indicator to be in its own case and to be suitably marked. Cases to be conveniently stowed.

There will be in the forward engine-room, in addition to the above:

A Lane's improved spring compound-gauge on the auxiliary condenser;

A counter or revolution-indicator on the auxiliary pumping-engine.

All the above gauges, clocks, and counters are to have dials of at least 8½ inches diameter.

There will also be in each engine-room a steam-gauge on the auxiliary steam-pipe, as before specified; also a steam-gauge on the steam-pipe to intermediate and low-pressure cylinder-jackets. All instrument casings and fittings to be of polished brass. All thermometers to be permanent fixtures, with stems and bulbs protected.

Each blowing-engine in fire-rooms will be fitted with an approved revolution-indicator. All gauges, thermometers, and revolution-indicators in engine-rooms will be suitably engraved, on dials or elsewhere, to show to what they are connected.

LOG-DESKS.

A desk of approved pattern, with locked drawer, is to be fitted in each engine-room where directed.

INDICATOR FITTINGS AND MOTIONS.

An indicator connection is to be made to each end of each cylinder of main engines as near as possible to the bore or the cylinder, and so as to be easily accessible. Each indicatof when in place is to be connected to but one end of a cylinder. The connecting-pipes are to be one-inch bore, without bends. The indicator-motion of each engine is to be so fitted that both indicators on its cylinder can be connected at the same time. The motions of the indicator-barrels must be accurately coincident with the motion of the corresponding pistons. The steam-cylinders of all auxiliary engines are to have holes tapped for indicator fittings and then plugged. These engines are to have portable indicator motions fitted, then removed and suitably marked and stored. When auxiliary engines are duplicated, but one set of indicator-motion fittings need be supplied for all of each kind.

ENGINE-ROOM TELEGRAPHS.

A repeating telegraph of approved pattern is to be fitted in each engine-room and connected to transmitters in conning-tower, in wheel-house, and on bridge. The connections are to be made in such a manner that the chance of derangement shall be minimized.

SPEAKING-TUBES.

Speaking-tubes will be made of copper not less than No. 20 B. W. G. They will connect each engine-room with each fire-room; the engine-rooms with each other; the fire-rooms

with each other; each engine-room to the wheel-house, conning-tower, bridge, and to the chief engineer's room; each fire room with the upper deck close to the top of the ash-hoist and elsewhere, as required. Each tube will be fitted at each end with a mouth-piece and approved annunciator; the mouth-pieces to be connected to short flexible pipes where required. All mouth-pieces or pipes to be plainly marked. The tubes will be suitably cased where necessary.

REVOLUTION-INDICATORS.

Revolution-indicators are to be of such approved pattern as shall not be affected to a perceptible degree by the motion of the ship or by changes of temperature. They must be worked off the engines by positive motions, and must be so fitted that changes of engine speed shall not produce violent fluctuations of the indices.

TELL-TALES.

Tell-tales with proper connections are to be fitted on the bridge and in the conning-tower, to show the direction of motion of the propelling-engines.

GOVERNORS.

An efficient governor of approved type is to be fitted to each propelling-engine and connected to the governor-throttle before specified.

LUBRICATION.

All working parts of machinery are to be fitted with efficient lubricators with capacity for sufficient oil for four hours' running. Each main crank-pin is to have a centrifugal oiler; each to be fed by a pipe from an oil-box on top of the adjoining main-bearing. Each main-bearing is to have an oil-box with wick-tubes, the back half of the box being fitted for water. The cross-heads are to be lubricated by telescopic-gear, as per drawings. Each main eccentric will have a

wiper oiling-gear, taking oil from cups supported by the water-service pipes. The thrust-bearings will have oil-boxes similar to those on main-bearings. The oil-cups on main valve-chests will be as before specified. There will be fitted to each main steam-pipe, close to valve-chest, a Siebert, or equivalent, sight-feed oil-cup of two quarts capacity. There will be smaller sight-feed cups on each circulating, blowing, main-feed, and bilge-pump engine; all sight-feed cups to have ample condensing surface on their steam-pipes. Each blower-engine will have a continuous automatic lubricator of approved pattern. All working parts for which oil-cups are not specified or shown in drawings will have oiling-gear of approved design, such that they can be oiled without slowing. All the oiling of each auxiliary engine to be done by one oil-box where practicable. All fixed oil-cups are to have hinged covers, with stops to prevent being opened too far. Moving oil-cups, where necessary, will have removable covers. The supply of oil to various parts is to be easily regulated. All oil-cups and their fittings, except such as are cast on bearings, are to be of finished cast-brass.

OIL-DRIPS.

All fixed bearings will have drip-cups cast on where possible, otherwise they will be of cast-brass, properly applied. All moving parts will have drip-cups or pans cast on engine-frames where possible, otherwise to be substantially made of sheet-brass. All drip-cups will have drain-pipes and cocks of at least $\frac{1}{2}$ inch diameter which can be used while the engines are in operation.

ASH-SPRINKLERS.

A cock for wetting down ashes will be fitted in each fire-room as shown, and will be fitted with all necessary hose, couplings, and nozzles.

JOURNAL-BOXES.

All journals or moving parts of iron or steel are to run, unless otherwise specified, in composition boxes. These boxes are to be lined with approved anti-friction metal where shown on drawings.

MANDRELS FOR WHITE-METAL BEARINGS.

Cast-iron mandrels, as shown, are to be furnished for forming the white-metal linings of crank-pin, crank-shaft, line-shaft, and thrust-bearings. All these to be smoothly and accurately turned to size, and packed so as to be perfectly protected.

STUFFING-BOXES.

All iron stuffing-boxes are to have composition bushings. All glands are to be of composition. Metallic packing of approved pattern will be fitted to piston-rod and valve-stem stuffing-boxes, and elsewhere as specified. All glands not fitted with pinion-nuts and spur-rings will have lock-nuts and split-pins.

PUMP-CYLINDERS.

All pump-cylinders, together with their valve-boxes and fittings, will be made of composition. Air-chambers will be fitted on the delivery sides of pumps or in the pipes, as may be directed.

BOLTS AND NUTS.

All bolt-heads and nuts, except in special cases, are to conform to the United States Navy standard. Screw-threads on bolts and nuts must in all cases conform to the above standard. All finished bolts, except as directed, are to be kept from turning by dowels or other suitable devices. All bolts on moving parts and on pillow-blocks are to be fitted with lock-nuts, and the bolts will extend beyond the nuts without threads, will be finished hemispherically, and fitted with split-pins or other approved safety device.

GEAR FOR WORKING VALVES FROM DECK.

The rods for working from the main deck the safety-valves, main steam-pipe stop-valves, and engine stop-valves, will be guided and supported on deck by cast composition standards, left rough and painted. Each rod will have a hand-wheel at least 3 feet above the deck. The stop-valve hand-wheels are to be 16 inches in diameter and those for the safety-valves 12 inches in diameter. The wheels will be of brass, polished, and will have their rims connected with the hubs by plain discs without holes in them. Or in lieu of hand-wheels, if directed, polished brass bar-handles will be fitted to squares on the turning-rods, and will be stowed in beckets on bulkheads. All hand-wheels to be engraved with name; or cast-brass label-plates with polished raised letters will be fixed to adjoining bulkheads.

SUPPORTS FOR LAMPS.

Supports for lamps will be fitted as and where directed.

LIFTING-GEAR.

Efficient lifting-gear, consisting of traveler-bars and pulleys, deck-beam clamps, turn-buckles, shackles, hooks, eye-bolts, and as may be directed, will be fitted wherever required for lifting parts of the machinery for overhauling and repairing.

OIL-TANKS.

Four oil-tanks, of 250 gallons capacity each, will be fitted where directed, with facilities for filling from deck. They will be made of wrought-iron not less than $\frac{1}{8}$ inch thick, and each will have a man-hole and cover near the top, and a locked-cock for drawing oil. In each engine-room there will be fitted two copper oil-tanks of 20 gallons each and two of 8 gallons each, and in each fire-room one of 5 gallons, all with lock-cocks. All oil-tanks will be fitted with drip-pans.

An iron tallow-tank, divided into two parts, with hinged covers, will be fitted where directed.

VENTILATORS.

Ventilators, with cowls well above the awnings, are to be fitted, two to each fire-room and three to each engine-room, of sizes shown in drawings.

The lower parts of the fire-room ventilators will be rectangular and will connect with the air-ducts to blowers. The ventilator-shafts are to be made of wrought-iron or steel not less than $\frac{1}{8}$ inch thick, and the cowls will be made of copper, No. 12 B. W. G., not planished. The base-rings of cowls will be of cast composition, finished on working parts but left unfinished on the outside. All cowls are to be fitted with gear for turning them from engine-rooms and fire-rooms; the gear to be of composition, except the spindles, which will be of wrought-iron. Brass hand-wheels or T-handles will be fitted to spindles in engine and fire-rooms. Doors at bottoms of fire-room ventilators will be so fitted that natural draught can be used and so that any blower can be shut off if desired.

INSTRUMENTS AND TOOLS.

The following instruments and tools are to be furnished in addition to those elsewhere specified, viz:

Two Thompson indicators of the same kind as furnished for the main engines; each with springs of 80, 64, 40, and 20 pounds to the inch; each in its own case, with fittings complete, and with two extra cock-attachments.

Two spare water-thermometers.

Two spare steam-thermometers.

One standardized thermometer in suitable case, with certificate of standardization.

One set of wrenches complete for each engine-room and for each fire-room, to be fitted to all nuts in their respective compartments, plainly marked with sizes, and fitted in iron racks of approved pattern. The wrenches for nuts of bolts less than one inch diameter will be finished, and for all over two inches diameter will be box-wrenches, where such can be used. Socket-wrenches to be furnished where required. Open-end

wrenches are to be of steel or of wrought-iron, with case-hardened jaws; all others to be of wrought-iron or cast-steel.

One pair of taps, on rod, for tapping front and back tube-sheets of main boilers at one operation. This is to be a duplicate of that used in originally tapping the sheets, and is to be so packed as to be perfectly protected from injury.

A similar pair of taps for the auxiliary boilers.

A fixed trammel for setting the main slide-valves without removing covers; the valve-stems to be properly marked for this purpose.

Fixed trammels or gauges for aligning crank-shafts; brass pins to be let into pillow-blocks and center-marked for this purpose.

Two complete sets of fire-tools for each fire-room.

Twelve coal-buckets and twelve ash-buckets.

All trammels and gauges to have protecting cases; all instruments and tools to be conveniently stowed.

DUPLICATE PIECES.

The following duplicate pieces, in addition to others specified, are to be furnished, fitted and ready for use, viz:

One set of valves for each pump.

One seat, with guards and bolts complete, for foot-valves, and one for delivery-valves of air-pumps.

One-half set of follower-bolts and nuts for each steam-piston, and one for each air-pump piston.

One-half set of springs for each steam-piston.

One set of brasses for each crank-shaft journal.

One set of brasses for each crank-pin journal.

One set of brasses for each cross-head journal.

One composition shoe for each cross-head.

One set of brasses for each thrust-bearing.

Three extra blades for each propeller, of such dimensions as may be directed, fitted to propeller-bosses.

One complete set of brasses for each main engine valve-gear.

One complete set of brasses for each circulating-pump engine, each main feed-pump, each bilge-pump, and each blowing-engine.

One hundred stay-tubes, threaded to fit threads in tube-sheets, with ends wrapped in canvas.

Three hundred ordinary boiler-tubes, swelled at one end and annealed ready for use. All boiler-tubes to be securely stowed in racks, or as directed.

Two hundred condenser-tubes, packed in boxes.

Fifty condenser-tube glands.

One spare spring for each safety-valve and relief-valve.

One spare basket for each Macomb bilge-strainer.

One-eighth of a set of grate-bars and bearers.

All duplicate pieces not of brass are to be painted with three coats of white lead and oil, and well lashed in tarred canvas, with the name painted on outside. Brass pieces are to be marked or stamped. All pieces to be stowed in an approved manner.

SECURING ENGINES IN SHIP.

The main engine-seatings will have tops of hard wood, of approved kind, bolted on as shown in drawings, and planed to a true surface. The engines will be placed directly on the wooden beds and securely bolted with finished through holding-down bolts with locked nuts at upper ends. Pillow-blocks and thrust-bearings will be secured in the same manner. When finally secured all shafting must be accurately in line, with the vessel at load-draught and ordinary stowage. The cylinder-axes must be parallel to each other, accurately in the plane of crank-shaft, perpendicular to the journals, and pointing to the centers of crank-pins. The air-pumps must be in perfect line with the low-pressure cylinders.

The auxiliary engines will have their seatings faired with similar wooden tops where necessary, and will be bolted similarly to main engines. All parts of machinery and boilers are to be secured in an approved manner to prevent displace-

ment when the vessel is used for ramming. The contractors for the hull will supply the labor to fit the seatings to the engines, boilers, and auxiliaries.

MATERIALS AND WORKMANSHIP.

All castings must be sound and true to form, and before being painted must be well cleaned of sand and scale and all fins and roughness removed.

No imperfect casting or unsound forging will be used if the defect affects the strength, or to a marked degree its sightliness.

All nuts on rough castings are to fit facings raised above the surface. All flanges of castings are to be faced, and those coupled together are to have their edges made fair with each other. The facings of all circular flanges are to be grooved.

All bolt-holes in permanently fixed parts are to be reamed or drilled fair and true in place, and the bodies of bolts finished to fit them snugly.

All threads on bolts and nuts are to be of the United States Navy standard.

All pipes beneath floor-plates are to be connected by forged bolts and nuts of Tobin's metal.

All brasses are to fit loosely between collars of shafting.

All brasses or journals are to be properly channeled for the distribution of oil.

Packing for stuffing-boxes to be such as may be approved.

All small pins of working parts are to be well case-hardened.

All materials used in the construction of the machinery are to be of the best quality. The iron castings are to be made of the best pig-iron, not scrap.

Composition castings will be made of new materials. The various compositions will be by weight as follows, viz:

For all journal-boxes and guide-gibs, where not otherwise specified:

Copper, 6 parts;
Tin, 1 part;
Zinc, ½ part.

Tobin's metal:
Copper, 58.22 per cent.;
Tin, 2.30 per cent.;
Zinc, 39.48 per cent.

Naval brass:
Copper, 62 per cent.;
Tin, 1 per cent.;
Zinc, 37 per cent.

For composition not otherwise specified:
Copper, 88 per cent.;
Tin, 10 per cent.;
Zinc, 2 per cent.

Muntz metal to be of the best commercial quality.

Anti-friction metal to be of approved kind.

Where the drawings call for Muntz metal or naval brass, but not so stated in these specifications, Tobin's metal will be substituted.

Ornamental brass fittings are to be of good uniform color.

All castings are to be increased in thickness around core-holes. Core-holes are to be tapped and the core-plugs screwed in and locked.

All steel forgings are to be without welds and to be free from laminations.

All flanges, collars, and off-sets to have well-rounded fillets.

All boiler-plates are to be well cleaned of oxide-of-iron scale.

All flanged parts of boilers are to be annealed, after flanging, in an approved manner.

The steam-cylinders of all auxiliary engines are to be lagged, same as main engines.

India-rubber valves are to be made of the best Para caoutchouc, with no other ingredients whatever than sulphur and white oxide of zinc; the sulphur is not to exceed 3 per cent. and the oxide of zinc 70 per cent. The India-rubber is not to contain any remanufactured materials, and is to be of a homogeneous character throughout, thoroughly compressed, free from air-holes and all other imperfections.

All bolts for securing the boiler attachments are, where possible, to be screwed through the boiler-plates, with heads inside.

All work is to be, in every respect, of the first quality and executed in a workmanlike and substantial manner.

Any portion of the work, whether partially or entirely completed, found defective, must be removed and satisfactorily replaced without extra charge.

TESTS OF MATERIAL.

All materials used in the construction of the boilers, shafting, and steel castings will be tested in accordance with the "Instructions to Steel Inspectors," a copy of which accompanies these specifications.

All boiler and condenser-tubes must be tested to 300 pounds internal water-pressure before being put in place. India-rubber valves taken at random must stand a dry-heat test of 270° F. for one hour and a moist-heat test of 320° for three hours without the quality being impaired.

TESTS OF BOILERS AND MACHINERY.

Before the boilers are painted or placed in the vessel they will be tested under a pressure of 225 pounds to the square inch above atmospheric pressure. This pressure is to be obtained by the application of heat to water within the boilers; the water filling the boilers quite full.

Each high-pressure cylinder, jacket, and valve-chest, the steam-pipes and valves, the auxiliary engines, and all fittings and connections subjected to the boiler pressure are to be tested by water-pressure to 225 pounds to the square inch; the intermediate cylinders and connections to 150 pounds; the low-pressure cylinders and connections to 135 pounds; the condensers to 30 pounds; and the feed-tanks to 15 pounds. The pumps, valve-boxes, and air-vessels of the feed, fire, and bilge-pumps are to be tested to 250 pounds per square inch. The cylinders and condensers are to be tested before being placed on board, and must be so placed that all parts may be accessible for examination by the Inspector during the test.

All parts are also to be tested after being secured on board. No lagging or covering is to be on the cylinders or condensers during the tests.

PAINTING.

After a satisfactory test the boilers are to be painted on the outside with two coats of brown zinc and oil.

All engine-work, not finished, to be primed with two coats of brown zinc and oil, and when placed in position on board the vessel will be painted with two coats of paint of approved color. The shafting, when in place, is to be painted with two coats of white lead and oil, and the boiler-fronts with two coats of lamp-black and oil.

The smoke-pipes are to be thoroughly painted before and after erection on board. The ventilators and cowls will be painted similarly to the smoke-pipes, except the interiors of the cowls, which will be painted vermilion.

All steam-pipes not lagged with wood, all exhaust-pipes and water-supply and discharge pipes will be painted as may be hereafter directed.

PRELIMINARY TESTS AND TRIALS.

Steam is not to be raised in the boilers until after the water-test on board, unless desired for drying joints, for which purpose the pressure must not exceed 10 pounds per square inch.

After testing, steam will be raised in the boilers whenever required, to test the connections and the workings of all parts of main and auxiliary engines. All expense of such preliminary tests will be borne by the contractor.

INSPECTOR'S OFFICE.

A suitable office and draughting-room, properly furnished in all respects, fitted and heated, is to be provided by the contractor for the use of the Inspector of Machinery and his assistants during the building of the machinery and its erection on board.

RECORD OF WEIGHTS.

The actual finished weights of all machinery and appurtenances thereto as fitted, also all stores, spare machinery, and tools, will be weighed by the contractor before being placed in the vessel, and the weights certified to by the Superintending Naval Engineer, in a detailed account, and forwarded once a month both to the Bureaus of Steam Engineering and Construction and Repair; and a copy of the report of these weights will be furnished to the Superintending Naval Constructor by the Superintending Engineer, that he may have a complete record of the weights put in the vessel.

WORKING-DRAWINGS.

All drawings necessary for the prosecution of the work must be prepared by and at the expense of the contractor. Those which are merely developments of the drawings furnished and of these specifications will be subject to the approval of the Inspector of Machinery before the work is ordered or commenced.

In the drawings furnished, figured dimensions, where given, will be followed, and not scale dimensions, unless otherwise directed. All discrepancies discovered in drawings, or between drawings and specifications, will be referred to the Inspector of Machinery.

CHANGES IN PLANS.

The contractor must make no changes from the drawings furnished except as herein directed, or from the provisions of these specifications, without preparing complete plans of such proposed changes and submitting the same to the Department for approval.

DRAWINGS OF COMPLETED MACHINERY.

Draughtsmen will be employed by the Bureau of Steam Engineering, who will, under the direction of the Superintending Engineer, make a complete set of general and detail

drawings of the machinery and boilers as fitted. These plans will be forwarded to the Bureau of Steam Engineering as the work progresses.

OMISSIONS.

The engines, boilers, uptakes, and smoke-pipes, all auxiliaries, piping and connections, all sea-valves (except the cutting of the holes for the same), and all parts described in these specifications and in the official drawings are to be fitted complete to the vessel by the engine contractors, and any part of the machinery, or any article pertaining thereto, which may have been inadvertently omitted from these specifications or from the official drawings, but which is necessary for the proper completion of the vessel, is to be supplied by the contractor without extra charge.

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ADDENDA TO

SPECIFICATIONS FOR NOS. 4 AND 5.

AUXILIARY BOILER AND ATTACHMENTS.

There will be one cylindrical horizontal return fire-tube boiler for auxiliary purposes, placed where shown on drawings. It will be made of the same material and similar parts will be finished and fitted in the same manner as in the main boilers, except as specified below.

The boiler will be 8 feet external diameter and 8 feet long. The shell will be in one length of $\frac{11}{16}$ inch plates, with butted and double-strapped longitudinal seams. The heads, except the lower plate of the front head, will be $\frac{11}{16}$ inch thick. The tube-sheets, front and back, will be $\frac{13}{16}$ inch thick. The back and sides of combustion-chamber will be $\frac{1}{2}$ inch thick. There will be one corrugated furnace, 3 feet 3 inches least internal diameter, of $\frac{1}{2}$-inch plate. There will be 32 stay-tubes and 82 ordinary tubes, $2\frac{1}{4}$ inches external diameter, spaced $3\frac{1}{2}$ inches between centers horizontally and $3\frac{1}{4}$ inches vertically. The tubes will be 5 feet 8 inches long between tube-sheets. The back sheet of the combustion-chamber will be rounded over to form the top. The back sheet of the combustion-chamber will be stayed to the back head of the boiler by $1\frac{1}{4}$-inch stays spaced 7 inches vertically and horizontally, screwed into both plates and nutted; also by one horizontal row of heel-braces, spaced as above, connecting the curved top of combustion-chamber to the back head. The sides and bottom of combuscion-chamber will be stayed to the boiler-shell by one row of

1¼-inch screw-stays, fitted as above. The water-spaces at back and sides of combustion-chamber will be 5 inches wide. There will be two 15 x 12-inch man-holes in the lower part of the front head and one in the upper part, fitted with steel covers as in main boilers. There will be a hand-hole in the lower part of each head. There will be four 1¾-inch braces connecting the front head to the combustion-chamber, two at each lower man-hole. There will be six 2-inch braces from head to head just above the tubes. Above these braces the front and back heads will be curved inwardly in cylindrical form to meet the boiler-shell.

The grate will be 5 feet long, making a grate surface of about 16 square feet. The top of the bridge-wall will be carried back to meet the back of the combustion-chamber.

Five 12 x 6 x ½-inch rolled zinc protecting-plates will be fitted. The boiler will be firmly secured in two saddles and will be clothed with incombustible non-conducting material covered with galvanized iron. The uptake will be built similarly to those of the main boilers and will lead into the nearest smoke-pipe. The uptake will be fitted with a pivoted damper.

AUXILIARY BOILER ATTACHMENTS.

The auxiliary boiler will have the following attachments and fittings, viz:

One 4½-inch self-acting steam stop-valve, with a 2-inch stop-valve, attached for steam to distillers; the larger stop-valve to connect with the auxiliary steam-pipe;

One brass dry-pipe, 5 inches in diameter;

One 1¾-inch check-valve with internal pipe;

One 1¼-inch bottom blow-valve with internal pipe;

One 1-inch surface blow-valve with internal pipe;

Two 2½-inch spring safety-valves with lifting-gear, connected with escape-pipes;

Two glass water-gauges with outside pipes leading to top *and to near the bottom* of boiler;

Four gauge-cocks;
Two steam-gauges;
One sentinel-valve;
One drain-cock;
One salinometer-pot;
One air-cock.
All of the above to be of same pattern as for main boilers.

AUXILIARY FEED-TANK.

A feed-water tank of about 100 gallons capacity will be fitted in the auxiliary boiler fire-room. It will be supplied from a branch discharge from the auxiliary feed-pumps in main fire-rooms. It will be fitted with a glass water-gauge, an overflow-pipe, and a float-valve in the auxiliary boiler feed-pump suction-pipe.

AUXILIARY BOILER FEED-PUMP.

There will be in the auxiliary boiler fire-room a duplex pump of approved pattern, with water-cylinders having a capacity of about 14 cubic inches each. It will draw water from the sea and from the auxiliary feed-tank and will deliver into the auxiliary boiler feed-pipe only.